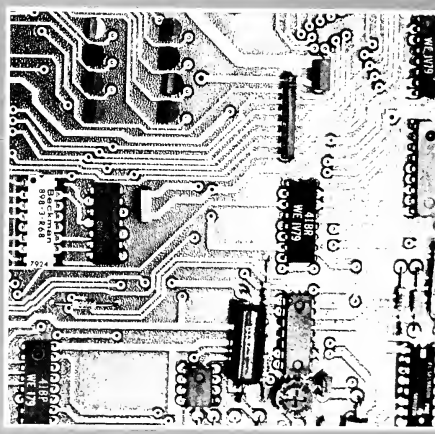
Graduate School of Engineering

Student Guide and Catalogue 1988/89

Northeastern University

Boston, Massachusetts



Graduate School of Engineering

Northeastern

University

Boston,

Massachusetts

Dear Graduate Student:

This Student Guide and Catalog is developed for your convenience in program planning. We are now in the fifth year of the new numbering system for courses. For convenience we have retained the old number in those courses where it is applicable.

The Graduate School of Engineering has offices in room 130 Snell Engineering Center. During the fall, winter and spring quarters it is staffed from 8:30 AM to 4:30 PM, Monday through Friday. We are open in the evenings during the academic year from 5:00 PM to 8:00PM on Mondays in Boston and in Burlington from 5:00 PM to 8:00 PM on Thursdays and During the summer we are staffed from 8:00 AM to 5:30 PM, Monday through Thursday. Administrative matters should be referred to us. The staff consists of:

David R. Freeman, Assoc. Dean and Director
Stephen L. Gibson, Assistant Director
Jennifer A. Black, Administrative Assistant
Hattie M. Williams, Secretary
Phyllis M. Eiro, Secretary

You may reach this office by calling (617) 437-2711.

David R. Freeman
Associate Dean and Director
Graduate School of Engineering

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PRESIDENT'S MESSAGE

We are pleased that you have selected Northeastern as the university for your graduate studies. Our graduate programs offer students academic excellence in an environment oriented to both scholarship and practical skills. The University is committed to having the highest quality faculty and to supporting research in all its disciplines.

Northeastern University offers a variety of programs within each of its nine graduate and professional schools. Each program has been designed to meet the interests and needs of graduate students and the professional climate of the 1980's. As a graduate student at Northeastern, you will find yourself working with students from diverse personal and geographic backgrounds, but with a common commitment to search and learn. These elements, in combination with our Boston location and proximity to many cultural attractions, help foster an exciting educational environment.

I wish you great success in your chosen program of study and look forward to greeting you at Northeastern.

Kenneth G. Ryder
President

GRADUATE DEGREES AND PROGRAMS AT NORTHEASTERN UNIVERSITY

Graduate School of Arts and Sciences

Master of Arts
- Economics
- English
- History
- Journalism
- Political Science
- Psychology: Applied Behavioral Analysis
- Sociology
- Social Anthropology
- Writing

Master of Science
- Biology
- Chemistry
- Economic Policy and Planning
- Law, Policy & Society*
- Mathematics
- Physics

Master of Science in Health Science

Master of Public Administration

Master of Journalism
- News Media Management

Master of Technical and Professional Writing

Doctor of Philosophy
- Biology
- Chemistry
- Economics
- Law, Policy & Society*
- Mathematics
- Physics
- Psychology: Experimental Psychology
- Sociology

Certificate of Advanced Graduate Study
- Advanced Literary Study

Nondegree Certificate Program

- Economics of Manpower and Development Planning
- Technical Writing Internship Training Program

Graduate School of Boston-Bouve College of Human Development Professions

Master of Education
- Consulting Teacher of Reading
- Counseling
- Curriculum and Instruction
- Educational Research
- Human Development
- Rehabilitation
- Special Education

Master of Science
- Counseling Psychology
- Physical Education
- Physical Therapy
- Recreation Management
- Speech-Language Pathology and Audiology

Certificate of Advanced Graduate Study
- Counseling
- Educational Administration
- Rehabilitation

Doctor of Education
Leadership: Administration and Supervision
- Counseling
- Educational Administration
- Rehabilitation Administration

Non-Degree Programs
- Elementary and Secondary Education
- Moderate and Severe Special Needs

Graduate School of Business Administration
Master of Business Administration
- Cooperative Education MBA Program
- Full-time MBA
- Part-time MBA
- High Tech MBA
- Executive MBA

Non-Degree Certificate Programs
- Advanced Study in Business Administration

Graduate School of Computer Science
Master of Science in Computer Science
- Artificial Intelligence
- Communications and Networks
- Databases
- Interactive Systems Design
- Systems Software
- Theory

Graduate School of Criminal Justice
Master of Science in Criminal Justice
- Administration and Planning
- Criminology and Research
- Security Administration
- Multidisciplinary Concentration

Graduate School of Engineering
Master of Science (unspecified)
- Chemical Engineering
- Civil Engineering
- Electrical Engineering
- Industrial Engineering
- Mechanical Engineering

Master of Science in Chemical Engineering

Master of Science in Civil Engineering
- Construction
- Environmental
- Geotechnical
- Structures
- Transportation

Master of Science in Computer Systems Engineering
- CAD/CAM
- Engineering Software Design
- Robotics

Master of Science in Electrical Engineering
- Communications and Signal Processing
- Computer Engineering
- Control Systems and Signal Processing
- Electronic Circuits and Semiconductor Devices
- Fields, Waves and Optics
- Power Systems

Master of Science in Engineering Management
- Computer and Information Systems
- General Program
- Manufacturing Systems
- Operations Research
- Quality Control and Reliability Analysis

Master of Science in Industrial Engineering
- Computer and Information Systems
- General Program
- Manufacturing Systems
- Operations Research
- Quality Control and Reliability Analysis

Master of Science in Information Systems

Master of Science in Mechanical Engineering
- Material Science and Engineering
- Mechanics
- Thermofluid Engineering

Electrical Engineer Degree

Industrial Engineer Degree

Mechanical Engineer Degree

Doctor of Engineering
- Chemical Engineering

Doctor of Philosophy
- Chemical Engineering
- Civil Engineering
- Electrical Engineering
- Industrial Engineering and Information Systems
- Mechanical Engineering

Pharmacy and Allied Health Professions

Master of Science
- Biomedical Science
- Hospital Pharmacy
- Medical Laboratory Science
- Medicinal Chemistry
- Pharmacology

Master of Health Professions
- General Option
- Health Policy
- Physician Assistant
- Regulatory Toxicology

Doctor of Philosophy

Biomedical Science with specialization in
- Medical Laboratory Science
- Medicinal Chemistry
- Pharmaceutical Sciences
- Pharmacology
- Toxicology

Doctor of Pharmacy

Non-Degree Certificate Programs
- Health Record Administration
- Medical Technology
- Physician Assistant
- Respiratory Therapy

Professional Schools

Graduate School of Professional Accounting

Master of Science in Accounting

School of Law

Juris Doctor

* Interdisciplinary Program
** Interdisciplinary Degree Program

ABOUT NORTHEASTERN UNIVERSITY

Among the nation's largest private universities, Northeastern University distinguishes itself not only by its immutable dedication to excellence in research and study, but also by its dedication to discovering community educational needs and meeting them. The University has not attempted to duplicate the programs of other institutions, but has sought to pioneer new areas of educational service from its beginning in 1898. Northeastern's roots can be found in the "Evening Institute for Young Men," founded in Boston in 1898. Classes in Law were offered at a reasonable cost during the evening for those who worked during the day. The first evening law school in Boston quickly expanded to include other disciplines, and soon added an innovative daytime program which offered opportunities to "earn while you learn." By the time Northeastern was incorporated as a university in 1922, the school had committed itself to "cooperative education by day, adult education in the evening".

Over half century later, Northeastern University has become a large comprehensive university with eight undergraduate colleges, nine graduate and professional schools, numerous suburban campuses, and an extensive research division. Incorporated as a privately endowed, nonsectarian institution of higher learning under the General Laws of Massachusetts, Northeastern, like other private universities, is governed by a Board of Trustees, elected by and from the Northeastern University Corporation, which is composed of about 200 distinguished business and professional men and women across the country.

Northeastern University has developed a national reputation as the leader in cooperative education. The Cooperative Plan of Education, initiated by the College of Engineering in 1909 and subsequently adopted by the other colleges of the University, enables students to alternate periods of work and study. This educational method offers students an opportunity to gain valuable practical experience as an integral part of their education and also provides the means by which they may contribute substantially to the financing of their education. Begun at the full-time undergraduate level, the Plan has been extended to the graduate level in engineering, business administration, law, professional accounting, and criminal justice.

In the field of adult education, the University offers full and part-time graduate degree programs that are specifically designed to meet the needs and interests of adults who wish to further their education. The University's nine graduate and professional schools - Arts and Sciences, Boston-Bouve College of Human Development Professions, Business Administration, Computer Science (no Doctoral), Criminal Justice, Engineering, School of Law, Pharmacy and Allied Health, and Professional Accounting - offer programs leading to Master of Science and Doctoral degrees. The School of Engineering Technology and University College offer part-time undergraduate programs leading to Associate's and Bachelor's degrees (in humanities, business administration and technical disciplines), while the Division of Continuing Education offers nondegree courses.

Northeastern University is an exciting and dynamic university in which to pursue your academic aspirations. It is also a modern, urban institution dedicated to meeting the practical challenges of the times and the community.

RESEARCH AT NORTHEASTERN UNIVERSITY

Research and scholarship are an integral part of Northeastern University's continuing efforts to promote the intellectual growth and development that help to ensure the University's continued ability to provide quality education to its students.

The first formally organized research group at Northeastern University was the Bureau of Business Research, established in 1939 to study business principles and practices. Thereafter, research efforts on campus increased so rapidly that in 1954 a Faculty Committee on Development and Coordination of Research was established to help unify and provide direction to scholarly activity at Northeastern. From an initial grant of $10,000 awarded to the Physics Department by the Office of Naval Research in 1945, sponsorship for University research efforts has grown to involve millions of dollars each year.

Responsibility for fostering and coordinating the development of research at Northeastern currently resides with the Vice President for Research who is assisted by the University Council on Research and Scholarship and the Office of Sponsored Programs. A semi-annual newsletter entitled Re: Search brings information about the research and scholarly efforts of Northeastern University's faculty and students to the University community and the general public.

Northeastern's funding for research comes from a variety of sources including the National Institutes of Health, National Science Foundation, the National Endowment for the Humanities, IBM, Dow Chemical, and the Mellon Foundation. The University also contributes to many research projects through its own Research and Scholarship Development Fund.

Northeastern University has numerous distinguished faculty members, many of whom have received prestigious awards, including Sloan Scholarships, Guggenheim Fellowships, and National Institutes of Health Research Awards. Faculty members lecture the world over. In addition, many faculty members serve as U.S. government consultants and participate on a variety of national and international committees.

Current research activities span almost every academic field and include laboratory projects, theoretical studies, and technological applications. Research is under way in the areas of business, physical and biological science, social science, humanities, allied health professions, and engineering. Student participation in these activities can take place as part of regular academic programs in the form of specially designed independent studies or through cooperative work assignments. Research involvement is actively encouraged and is limited only by the student's own motivation and curiosity.

University Institutes and Research Centers

Northeastern University has also established a number of interdisciplinary institutes and research centers to provide administrative support and coordination for research efforts in key areas. The following are among those included in this category:

-Cooperative Education Research Center
-Center for Applied Social Research
-Arts and Sciences Center for Asian Studies
-Barnett Institute for Chemical Analysis and Materials Science
-Electron Microscopy Center
-Arts and Sciences Humanities Center
-Center for Electromagnetics Research
-Center for Labor Market Studies
-Marine Science and Maritime Studies Center
-Center for Medical Manpower Studies
-Arts and Sciences Center for Urban Studies
-Center for Urban and Regional Economic Studies
-Center for Integration of Engineering and Manufacturing
-Center for the Study of Sport in Society

Scholarly Journals

Several scholarly journals originate from Northeastern. These include: Studies in American Fiction; the New England Quarterly; The Scriblerian, Journal of Sports and Social Issues; Tennessee Williams Review; Romanticism: Past and Present; Health Values: Achieving High-Level Wellness.

NORTHEASTERN UNIVERSITY IN BOSTON

Historically, the city of Boston has played a pioneering role in American education. Today it has one of the largest and most diverse student populations in the country. Within a 25 mile radius of Northeastern University's campus are over 50 degree-granting institutions.

As a graduate student at Northeastern University, you will discover that part of the adventure of studying in Boston is exploring the cultural, educational, historical, and recreational offerings of the city. Northeastern is very much an urban university, and Boston is one of its richest resources.

Boston is both a city of tradition and a city of change. Centuries-old meeting houses are located beside striking contemporary office buildings and large-scale civic projects. This diversity is reflected in the cultural life of the city as well. Within a short distance of the campus are numerous renowned cultural centers such as Symphony Hall, the Museum of Fine Arts, the Isabella Stewart Gardner Museum, Horticultural Hall, and the Boston Public Library. Theater in Boston includes everything from pre-Broadway tryouts to experimental and college productions.

For those interested in sports, the Red Sox, Boston Celtics, Boston Bruins, and New England Patriots play all their home games in and around the Boston area.

The University is adjacent to the Fenway, a spacious and naturalistic park designed near the turn of the last century by Frederick Law Olmstead, the world famous landscape architect, that includes a beautiful rose garden and paths used extensively by Northeastern joggers.

Cape Cod and the North Shore are easily reached by car or public transportation for swimming, surfing, and boating. The scenic areas of northern New England are accessible for skiing, hiking, and mountain climbing.

Boston provides its student population with a stimulating environment in which to learn and grow. In turn, the considerable influence of its universities, colleges, and their student populations provides Boston with a young, vibrant and exciting ambience, quite possibly unequalled anywhere else.

FINANCIAL INFORMATION

Tuition and Fees

The tuition rate for students enrolled in the Graduate School of Engineering for the 1988-89 academic year is $235 per quarter hour of credit. Doctoral candidates making active use of University resources while in residence are charged an additional $600 per quarter residency for three quarters, while those registered for dissertation work being performed off campus must pay a $300 fee in addition to tuition. A continuation fee, equivalent to the tuition cost for one-half a quarter hour of credit for Master of Science and Engineer Degrees and one quarter hour of credit for Doctorate, is charged to students who have completed their course requirements but not their thesis requirements.

Tuition statements are mailed to students by the Bursar's Office and are payable by cash or check to Northeastern University on or before the date specified.

Other fees include a charge of $50 for late payment of tuition, a nonrefundable University Health Service fee of $320 each year for full-time students, a graduation fee of $40 for all degree candidates, and a Student Center fee of $12.50 per quarter for full-time students, and $.75 per quarter for part-time students enrolled in courses on the Boston campus.

Complete information regarding tuition and fees is provided in the current brochure Graduate School Expenses. Students should note that tuition rates and fees are subject to revision by the University's President and Board of Trustees at any time and may change eventually.

Tuition refund and procedures for withdrawal from courses is provided in section A5 under the Academic Policies and Procedures section of this student guide.

FINANCIAL ASSISTANCE

Northeastern University offers graduate students a variety of means for obtaining financial assistance. In addition to various types of assistantships awarded by the individual graduate schools, the Office of Financial Aid administers several forms of financial aid. A limited number of fellowships are also available to minority students through the African-American Institute, and each year there are also part-time residence hall staff positions available.

Graduate Assistantships

Of special interest to full-time graduate students are the variety of assistantships and fellowship programs. Awards are based on a student's previous academic performance. Assistantship applications are available from the Graduate School of Engineering Office.

Teaching and Administrative Assistantships currently offer a $7500 stipend and a $5,640 tuition scholarship for a nine-month (September to June) appointment. These awards require the performance of teaching or administrative functions for approximately twenty hours a week

Research Fellowships for Master of Science degree and doctoral candidates, including National Institutes of Health and National Science Foundation grants, are offered through a number of departments. Graduate students who perform research work for the department usually receive a compensatory stipend of $7500 (current amount) for a nine-month appointment in addition to tuition remission.

Northeastern University Tuition Assistantships (NUTA) provide up to $5,640 (based on current tuition rate of $235/qh) in tuition remission. The nine-month appointment is in exchange for ten hours per week of work.

Acceptance Conditions for Graduate Assistantships

Northeastern University, which is a member of the Council of Graduate Schools of the United States, subscribes to the following resolution of the Council: Acceptance of an offer of financial aid (such as a graduate scholarship, fellowship, traineeship, or assistantship) for the next academic year by an actual or prospective graduate student completes an agreement which both student and graduate school expect to honor. In those instances in which the student accepts the offer before April 15 and subsequently desires to withdraw, the student may submit in writing a resignation of the appointment at any time through April 15. However, an acceptance given or left in force after April 15 commits the student not to accept another offer without first obtaining a written release from the institution to which a commitment has been made. Similarly, an offer by an institution after April 15 is conditional on presentation by the student of the written release from any previously accepted offer.

Financial Aid Programs

The Office of Financial Aid offers several types of assistance to graduate students. All awards are based on financial need. Since the majority of these awards are sponsored by the Federal Government, the amount of aid granted is dependent upon the amount of funds allocated to Northeastern University each year.

In order to meet application deadlines for financial aid, students may have to apply for financial aid before they have been offered admission to the Graduate School. However, only those students who are accepted will be reviewed for financial aid. In addition, the University only awards financial aid to students who are U.S. citizens and permanent residents of the United States. Students who are studying in the United States on student visas are not eligible for federal assistance.

Northeastern University is a participant in the College Scholarship Service which utilizes the Financial Aid Form (FAF). All applicants for financial aid (including loans) must file an FAF in order to be considered. Northeastern University's Graduate Schools Financial Aid application and transcripts of financial aid history from other schools attended are also required. All application forms are available from the Office of Financial Aid, 254 Richards Hall, Northeastern University, Boston, MA 02115.

Perkins Loans

This program is available to full-time graduate students who show a high level of financial need. Graduate students may borrow up to $18,000 during the course of their entire educational careers. Repayment and interest do not begin until six months after the student ceases to carry at least a half-time academic load. Repayment may be extended over a ten year period with an interest rate of five percent per annum. No payments are required for up to three years while a borrower is serving in the Armed Forces, Peace Corps, VISTA, or while working as a full-time volunteer for a tax-exempt charitable organization performing service comparable to the service performed in Peace Corps or VISTA.

College Work-Study Program

This program is available to full-time graduate students who show financial need. It is designed to give students an opportunity to earn as much as $7.50 per hour working on jobs on or off campus in public or private nonprofit organizations. This program is administered solely by the Office of Financial Aid and should not be confused with the University's Cooperative Education Program.

Guaranteed Student Loan (GSL) Program

Under this program, students who demonstrate financial need, in accordance with guidelines established by the U.S. Department of Education, may borrow money for educational expenses from banks or other private lending institutions. Financial need is determined by the Financial Aid Office at Northeastern on the basis of information provided on the Financial Aid Form (FAF). Students must also be enrolled on at least a half-time basis, in a degree granting program, to be eligible for these loans.

The maximum annual borrowing limit is $7500 and the aggregate limit (including GSL's borrowed at the undergraduate level) is $54,750. The current interest rate is 8%, however students with outstanding GSL's borrowed at 7% or 9% will continue to borrow at that same rate. Information on specific terms, conditions, fees and repayment, as well as application forms, may be obtained from lending institutions and state guarantee agencies. You may also contact the Office of Financial Aid at Northeastern.

Please Note: Students must receive a financial aid award letter from the Office of Financial Aid before submitting the GSL application form to the Student Loan Office at Northeastern.

Scholarships

Northeastern University Minority Fellowships (NUMF) are to assist a limited number of minority students accepted for full-time study in the Graduate Schools of the University. The awards are made to students who demonstrate superior academic achievement and are competitive within each graduate school. Stipends cover tuition and fees. Applications may be obtained from the Graduate School Office.

Massachusetts Graduate Student Grant Program. This fund is provided by the Commonwealth of Massachusetts to assist needy residents pursuing Masters or Doctoral degrees on at least a half-time basis. The commonwealth has specified that Law, Pharmacy, and specific medical programs will not be eligible. The grants are also restricted to permanent Massachusetts residents, defined as those who have a permanent address in Massachusetts and have been living in Massachusetts for other than educational purposes for two full years prior to beginning the graduate program. The maximum grant is $4000, although awards vary depending on available funding and comparative financial need.

Martin Luther King, Jr. Scholarships. A limited number of full-time Martin Luther King, Jr., Scholarships are available. These Scholarships pay the recipient's full tuition and fees during the course of satisfactory graduate work. Further information and applications are available at the African-American Institute, Northeastern University, 40 Leon Street, Boston, Massachusetts 02115.

Residence Hall Staff Positions

A limited number of residence staff positions in housing facilities are available each year. Appointments carry a minimum compensation of room and board. Further information may be obtained from the Office of University Housing, 104-106 Ell Building.

Graduate Cooperative Education

The Graduate Program in Engineering offers the opportunity for Cooperative Education to its students. The number of offerings available to domestic students is limited and further restrictions are placed on international student placement. Students in the cooperative education option for graduate study may elect to follow either an alternating or a parallel schedule, according to availability. Both programs necessitate a minimum commitment of eighteen months for completion of Master of Science degree requirements.

The alternating schedule is sequenced to include full-time co-op employment for three- or six-month periods interspaced with periods of classroom study on a full-time academic basis of twelve to fourteen quarter hours minimum each quarter. The parallel schedule allows the graduate student to work simultaneously, approximately twenty hours per week, while carrying a minimum academic load of eight quarter hours per quarter.

GRADUATE SCHOOL OF ENGINEERING

GENERAL INFORMATION

The Graduate School of Engineering offers degree programs designed to help students prepare themselves for technical positions in industrial organizations, government laboratories, research laboratories, and educational institutions.

In addition to extensive day graduate programs, the Graduate School of Engineering offers Master of Science, Engineer Degree, and Doctoral Degree programs on a part-time basis in the evening. An interdisciplinary Doctor of Philosophy is also available for graduate students whose interests overlap two or more departments. All full-time day graduate programs in the five departments are offered at the Boston campus. The evening graduate programs offered through the Department of Electrical and Computer Engineering and the Department of Industrial Engineering and Information Systems are available at both the Boston campus and the suburban Burlington campus. The other three departments offer their evening graduate programs at the Boston campus only.

Northeastern University awards credit on a quarter-hour basis, with one quarter-hour credit roughly equivalent to three-fourths of a semester hour. The Master of Science degree requires a minimum of forty to forty-eight quarter-hour credits, depending on the specific program selected. In some cases, depending upon academic background, prerequisite courses are required. Part-time students who normally carry four quarter hours each term can generally complete their programs in three and a half to four years, while full-time students, who may take twelve to sixteen quarter hours each term, may earn their degrees in as little as one year. However, full-time students receiving some form of tuition assistantship or who are enrolled in the co-op plan or the Master of Science in Information Systems program must usually devote two years to completing their academic requirements.

The Master of Science degree with specification is granted to students who have earned a baccalaureate degree in the same engineering discipline as their graduate program. However, students who are admitted to the Industrial Engineering and Information Systems Department are exempted from this general policy and may earn the specified degree regardless of their undergraduate training. Students holding undergraduate degrees in disciplines that do not correspond to their graduate program or that have been conferred by colleges outside the United States are awarded the Master of Science degree without specification upon completion of their program requirements.*

*In some cases, the specified degree in civil engineering is granted to students who hold undergraduate degrees from overseas institutions.

SPECIAL PROGRAMS IN ENGINEERING

Women in Engineering

The Women in Engineering Program offers the opportunity for educational preparation to women who seek advanced professional positions in the field of computer or electrical engineering, but who lack the necessary background. The program leads to a Master of Science degree with a concentration in computer engineering, or in some cases to the Master of Science in Electrical Engineering degree. It is designed for women with undergraduate degrees in nonengineering areas such as mathematics, physics, natural science, and mathematics or science education. Graduate study is offered on a full- or part-time basis.

An individual educational program is developed for each student. The program includes a transitional educational experience designed to provide students with Master of Science degree program prerequisites. Women in Engineering also sponsors a series of career development seminars and other support services that address issues of specific interest to women planning a new career in engineering.

Women in Information Systems

The Women in Information Systems Program leads to a Master of Science in Information Systems degree. The program is designed for professional women with nontechnical degrees who seek the opportunity for a career move into the computer industry.

The program's goal is to provide a complete career transition in a short time frame by building new technical skills on the knowledge and professional experience base that students have previously acquired. The program begins with an initial full-time academic commitment of six months. Students are then offered help in locating co-op jobs where they will be expected to work forty hours a week earning industry-competitive, entry-level salaries while completing their Master of Science degree on a part-time basis. The entire program is designed to take two and one-half years to complete.

Industrial Fellowship Program

The Industrial Fellowship Program is a one-year Master of Science program in electrical and computer engineering. Students are selected and sponsored by their companies to attend a full-time graduate program for two to three days a week while retaining their full-time employment in the remaining days. The program is completed with a thesis in the summer months. The thesis topic is directly related to company work, and is jointly supervised by an industrial manager and an academic advisor.

Instructional Television Fixed Service

Daytime graduate courses in electrical engineering, mechanical engineering, and industrial engineering and information systems are broadcast live to companies that are members of Network Northeastern. An interactive audio system is a unique linkage feature between the classroom and the ITFS student. The ITFS program is geared to the part-time graduate student in industry. A student may also pursue evening classes at either the Boston campus or the suburban Burlington campus.

Degree Programs in Engineering

Department of Chemical Engineering
Master of Science in Chemical Engineering or Master of Science (unspecified)
Doctor of Engineering
Doctor of Philosophy

Department of Civil Engineering
Master of Science in Civil Engineering or Master of Science (unspecified)
- Construction Engineering
- Environmental Engineering
- Geotechnical Engineering
- Structures and Materials
- Transportation

Master of Science in Transportation (interdisciplinary)
Doctor of Philosophy

Computer Systems Engineering
CAD/CAM
Engineering Software Design
Robotics

Department of Electrical and Computer Engineering
Master of Science in Electrical Engineering or Master of Science (unspecified)
- Computer Engineering
- Communications and Signal Processing
- Control and Signal Processing
- Electronic Circuits and Semiconductor Devices
- Fields, Waves and Optics
- Power Systems
- Electrical Engineer

Doctor of Philosophy

Department of Industrial Engineering and Information Systems
Master of Science in Industrial Engineering
- Computer and Information Systems
- Manufacturing Systems
- Operations Research
- Quality Control and Reliability Analysis

Master of Science in Engineering Management
- Computer and Information Systems
- Manufacturing Systems
- Operations Research
- Quality Control and Reliability Analysis

Master of Science in Information Systems
Doctor of Philosophy
Industrial Engineer

Department of Mechanical Engineering
Master of Science in Mechanical Engineering or Master of Science (unspecified)
- Material Science and Engineering
- Mechanics
- Thermofluid Engineering

Mechanical Engineer
Doctor of Philosophy

Interdisciplinary Doctor of Philosophy

INTERDISCIPLINARY PHD PROGRAM

The Graduate School of Engineering offers the opportunity for an interdisciplinary doctoral program involving substantial work in two or more departments. A written proposal describing the areas of proposed study and research would have been submitted with the student's application. Interdisciplinary study requires favorable recommendation by the sponsoring doctoral degree-granting department and approval by authorized representatives of the graduate study committees of the departments appropriate to the disciplines covered by the student's proposal. The sponsoring department is the registration base of the student.

Formation of Interdisciplinary Committee

A student who has been accepted for interdisciplinary study must obtain the consent of an advisor who will direct his or her doctoral thesis. This advisor, who may or may not be a member of the registration department, will be chairman of the interdisciplinary committee for this student. A second member will be appointed from the registration department by its chairman. These two members will obtain one or more additional members or request the director of the graduate school to do so. At least two departments must be represented on the committee and a majority of the committee must come from doctoral degree-granting departments. The chairman of the registration department will notify the Director of the Graduate School of the membership of the committee as soon as arrangements are complete.

Duties of Interdisciplinary Committee

A member of the interdisciplinary committee who is also a member of the registration department will serve as the registration officer to approve the course registration for the student. A copy of the approved course registration must also be filed with the other committee members and with the graduate study committee of the registration department.

The interdisciplinary committee will be responsible for the administration of the qualifying examination, language examination, approval of the dissertation, and comprehensive examination. This committee must also certify to the registration department the completion of the requirements for the award of the doctoral degree.

The interdisciplinary committee must assure that the program of the student represents standards comparable to those of the registration department and that the program is not so broad that it has inadequate depth in any area.

The program of the student may be reviewed at any time by the Director of the Graduate School to determine whether objectives of the program are being met.

COMPUTER SYSTEMS ENGINEERING

The Graduate School of Engineering offers an interdisciplinary program leading to the degree of Master of Science in Computer Systems Engineering. Three major areas of concentration are available. These concentrations are:

CAD/CAM
Robotics
Engineering Software Design

This interdisciplinary program has courses drawn from Electrical and Computer Engineering, Industrial Engineering and Information Systems, Mechanical Engineering and the College of Computer Science.

The program may be pursued on a full-time, part-time or cooperative plan. Students have the opportunity to select courses from both the day and evening offerings. Each student will be assigned an advisor based upon the area of concentration chosen.

Master of Science Degree Requirements

A minimum of forty-eight quarter hours of graduate courses with a minimum grade point average of 3.0 is required. Refer to the regulations of the Graduate School of Engineering for detailed information on academic and administrative policies.

Students holding an engineering degree from an ABET accredited institution will qualify to apply for the Master of Science in Computer Systems Engineering. Students with a Bachelor of Science in the physical sciences may also apply. A Graduate Record Examination (GRE) is required of all applicants.

Prerequisite Courses

Students are expected to be proficient in a high-level language such as Pascal or Modula-2 and in Data Structures. Students in the Robotics concentration must also have a background in LISP. Applicants lacking this background will be asked to take these courses or their equivalent and up to 4 quarter hours of prerequisite course work may be applied to the required minimum. Determination of prerequisite needs will be made at the time of admission.

The following courses may be used for the prerequisite:

High level language
- IIS 3106 Elements of Structured Programming
- IIS 3115 Modula-2 for Engineers
- COM 1100 Pascal

Data Structures
- IIS 3604 Data Structures

LISP (Robotics majors)
- COM 1102 LISP

Course Requirements	Full or Part-Time Study
Required Core Courses	8 QH
Subject Area Required Courses	20 or 24 QH
Elective Courses	16 or 20 QH
Minimum Quarter Hours Required	48 QH

Required Core Courses		Credits
ME 3500	Computer Aided Graphics and Design	4
ECE 3311	Software Engineering	4
or		
IIS 3624	Software Engineering I	4

Subject Area Required Courses

CAD/CAM

ECE 3451 or IIS 3103 Optimization.....4
ME 3468 Robot Mechanics and Control.....4
ME 3510 Manufacturing Machine Programming.....4
IIS 3309 Computer Methods in Manufacturing.....4
IIS 3311 Computer Aided Engineering.....4

Robotics

COM 3410 Principles of Artificial Intelligence.....4
ECE 3381 Classical Control Theory.....4
ECE 3540 Digital Control Systems.....4
ECE 3463 Robotic Sensors.....4
ECE 3466 Intelligent Robots.....4
ME 3468 Robot Mechanics and Control.....4

Engineering Software Design

IIS 3625 Software Engineering II.....4
IIS 3607 Operating Systems & Systems Software.....4
IIS 3217 Engineering Project Management.....4
IIS 3610 Computer Architecture.....4
IIS 3651 Software Engineering Project.....4

Course Descriptions

COM 3410 is described here since it is from another college; all other courses will be found in the section appropriate to the course prefix.

Prefix to Course #	Department
ECE	Electrical and Computer Engineering
IIS	Industrial Engineering and Information Systems
ME	Mechanical Engineering

COM 3410 Foundations of Artificial Intelligence (4QH)

Searching, goals, and plans. Heuristics. Representation of knowledge: nets, frames, and inheritance. Logic and its role in Artificial Intelligence. Selected applications of these ideas in other areas of Artificial Intelligence. Prep. Working knowledge of LISP.

Advisors

CAD/CAM	Prof. Zeid
Robotics	Prof. Proakis
Engineering Software Design	(A-L) Prof. Mourant
	(M-Z) Prof. Kokar

DEPARTMENT OF CHEMICAL ENGINEERING

The Department of Chemical Engineering offers the degrees of Master of Science in Chemical Engineering, Master of Science without specification, Doctor of Engineering, and Doctor of Philosophy. The Master of Science degree in Chemical Engineering may be pursued on either a full-time or a part-time basis. A full-time student may apply for participation in the Cooperative Plan. The Master of Science degree without specification must be pursued on a continuous full-time basis. The Doctor of Engineering and Doctor of Philosophy degrees are pursued on a continuous full-time basis consistent with the residence requirements for the degree.

Full-time Master of Science students and Doctoral candidates are able to select thesis topics from a diverse range of faculty research interests. Graduate student seminars are held on a regular basis and provide an interactive forum for learning about departmental research and exchanging ideas. Most courses are offered in the late afternoon or early evening to make them readily accessible to part-time students pursuing full-time industrial careers.

Master of Science students wishing to switch their status from part-time to full-time must notify the Chemical Engineering Department and make formal petition with the Graduate School of Engineering. Such requests are usually granted for the full-time program to begin in the fall quarter. Please refer to the regulations of the Graduate School of Engineering for information on academic and administrative policies.

Master of Science Degree Requirements

A minimum of 40 quarter hours of academic work is required of all students. A thesis of ten quarter hours of credit and one seminar course are required of all continuous and cooperative full-time students who qualify for the Master of Science in Chemical Engineering, in addition to the required courses. The sequence of courses which students take on this plan is established by their advisor. Part-time students may progress according to their abilities within the seven year time limit. The thesis and seminar course are not required for part-time students and unspecified Master of Science degree candidates.

A Master of Science in Chemical Engineering will be awarded to those students with a Bachelor of Science in Chemical Engineering or a closely-allied engineering field. Students with a Bachelor of Science degree in other engineering or related science fields and an appropriate background of preparation may qualify for the degree of Master of Science with specification. Such students are required to complete supplementary undergraduate work, which is not included in the minimum course requirements, on a full-time (non-cooperative education) basis.

Course Requirements	Master of Science Thesis Option	Master of Science Non-Thesis Option
Required Core Courses	12 QH	12 QH
Master of Science Thesis	10 QH	0 QH
Seminar	2 QH	0 QH
Elective Courses**	16 QH	32 QH
Minimum Quarter Hours Required*	40 QH	44 QH

*exclusive of any preparatory courses

** Students may complete a maximum of 10 QH (Thesis Option) or 12 QH (Non-Thesis Option) of course work outside of the Chemical Engineering Department with approval of the Chemical Engineering Department

Required Core Courses (2QH equivalents are in parentheses) Credits

CHE 3300 (3301,3302) Chemical Engineering Mathematics.....4
CHE 3310 (3311,3312) Chemical Engineering Thermodynamics.....4
CHE 3320 (3321,3322) Separation Processes.....4
CHE 3330 (3331,3332) Chemical Process Control.....4
CHE 3340 (3341,3342) Heterogeneous Catalysis.....4
CHE 3350 (3351,3352) Chemical Process Heat Transfer.....4

Master of Science Thesis CHE 3860.....10
Seminar CHE 3691.....2
Elective Courses
CHE 3400 (3401,3420) Advanced Chemical Engineering Calculations.....4
CHE 3410 (3411,3412) Numerical Techniques in Chemical Engineering...4
CHE 3432 Chemical Data Estimation.....2
CHE 3450 Analytical and Numerical Techniques.....4
CHE 3500 (3501,3502) Transport Phenomena.....4
CHE 3510 (3511,3512) Modeling and Simulation of Chemical Processes..4
CHE 3520 (3521,3522) Computer Process Control.....4
CHE 3530 (3531,3532) Adv. Management Techniques in Chemical Ind.....4
CHE 3540 (3541,3542) Advanced Plant Design Concepts.....4
CHE 3543 Advanced Plant Design Concepts.....2
CHE 3560 (3561,3562) Fluid Mechanics.....4
CHE 3600 (3601,3602) Polymer Science.....4
CHE 3620 (3621,3622) Principles of Polymerization.....4
CHE 3630 (3631,3632) Chemical Process Pollution Control.....4
CHE 3660 Solar Energy Thermal Processes.....2
CHE 3663 (3664,3665) Fundamentals of Polymer Processing.....4
CHE 3670 (3701,3702) Special Topics in Chemical Engineering.....4
CHE 3671 (3672,3673) Kinetics of Chemical Processes.....4
CHE 3680 Corrosion Fundamentals.....2

The Doctoral Degrees

The Chemical Engineering Department offers the degrees of Doctor of Philosophy and Doctor of Engineering. These programs are offered on a continuous full-time basis. The following material outlines the requirements for both doctoral programs; detailed descriptions of the dissertation for the PhD and the engineering problem for the DEng are presented separately.

Qualifying Examination and Degree Candidacy

Each student admitted to the program will initially have the status of doctoral student. Successful completion of the qualifying examination is the minimum required for consideration as a doctoral degree candidate. The qualifying examination includes both written and oral parts. The written part is normally given in the winter quarter. The oral examination will test general comprehension and is normally given at the time of the dissertation topic proposal presentation. The written examination, in general, will cover the following areas: Thermodynamics, Kinetics and Reactor Design Process Control, Unit Operations (including Transport Phenomena), Process Design, and Applied Chemistry.

Course Requirements

The course requirements, in addition to the minimum requirements for establishing degree candidacy, will be determined by the departmental graduate committee.

Language Requirement

There is no foreign language requirement for Doctor of Engineering and Doctor of Philosophy degrees. The candidate must be proficient in technical writing and oral presentation in the English language. Appropriate course work may be required by the dissertation or problem committee.

Residence Requirement

The residence requirement is satisfied by one year of full-time graduate work after admission as a doctoral student. However, it is expected that at least two years of full-time graduate study will be required beyond the Master of Science degree.

Dissertation Prospectus/Outline

After passing the qualifying examination, the doctoral degree candidate must prepare a dissertation prospectus/outline depicting the research on an engineering problem which will be conducted, analyzed and presented in the dissertation. The cover sheet is signed by each member of the dissertation committee to indicate approval of the topic and its plan of execution.

Comprehensive Examination

The comprehensive examination is combined with the final oral examination and is given after the dissertation has been completed and approved by the dissertation advisor. This examination is based upon the subject matter of the dissertation and a defense of it.

Final Oral Examination

The final oral examination is taken after completion of all other requirements for the degree. The final oral examination will include the subject matter of the doctoral dissertation and significant developments in the field of the dissertation work. Other fields may be included if recommended by the examination committee.

The Doctor of Philosophy Degree

Dissertation

After degree candidacy has been established, a candidate must complete a dissertation which embodies the results of extended original research and includes material suitable for publication. An individual may choose his or her dissertation topic and supervisor upon becoming a doctoral student. In most cases selection of topic will be made immediately after the student has established candidacy for the PhD degree. The student will be expected to discuss with the staff their PhD dissertation topics offerings. After these discussions, the student shall notify the advisor, the department head, and the chairman of the departmental graduate committee in writing of his or her choice of dissertation topic and advisor. The chairman of the departmental graduate committee after consultation with the advisor shall appoint an appropriate dissertation committee. This committee shall be kept informed of the progress of the dissertation and will approve the dissertation in its final form.

The Doctor of Engineering Degree

Engineering Problem

The Engineering Problem advisor will be selected by the degree candidate after consultation with the faculty. Approval of the topic for the Problem rests with the Problem advisor and the departmental graduate committee. The Engineering Problem is not a research problem but rather an engineering problem in depth. It may include elements of design, economics, business management principles, and process development. In general, it will not include laboratory investigations. Normally, the Engineering Problem will be solved on campus. Regardless of the arrangements made for the Engineering Problem, no off-campus advisor will be approved. Only the Problem advisor will specify the nature and requirements of the Problem, and the findings and results remain the property of the advisor and the University to be published as they determine.

Faculty

Ralph A. Buonopane, Chairman

Professors

Williams, John A., PhD, Case Western Reserve University; fuels
Wise, Donald L., PhD, University of Pittsburgh; biotechnology, biomaterials, bioconversions

Associate Professors

Buonopane, Ralph A., PhD, Northeastern University; heat and mass transfer
Goodwin, Bernard M., ScD, MIT; computer applications, applied math
Stewart, Richard R.,PhD, Clemson University; process control

Assistant Professor

McMillan, Scott T., PhD, Georgia Institute of Technology; biomedical/biochemical
Willey, Ronald, J., PhD, University of Massachusetts, Amherst; heterogeneous catalysis

Advisors

MS Specified	(A-L) Prof. Stewart
	(M-Z) Prof. Goodwin
MS Unspecified	(A-Z) Prof. Buonopane
Doctoral Programs	(A-Z) Prof. Williams

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; however, the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine the courses that are actually offered in any given quarter and the day and time.

CHE 3300 Chemical Engineering Mathematics (4QH)
(formerly 04.802) Fall Quarter, Alternating Years
Formulation and solution of problems involving advanced calculus as they arise in chemical engineering situations. Methods covered will include ordinary differential equations, series solutions, complex variables. Laplace transforms, partial differential equations, and matrix operations. Emphasis will be placed on methods for formulating the problems. It will be assumed that the student has been exposed to some of these topics in appropriate mathematics courses. Prep. BS degree in Chemical Engineering including mathematical analysis.

CHE 3301 Chemical Engineering Mathematics I (2QH)
Fall Quarter, As Announced
CHE 3301 and CHE 3302 cover the same material with the same prerequisites as CHE 3300, but in two 2QH courses.

CHE 3302 Chemical Engineering Mathematics II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3301. Prep. CHE 3301.

CHE 3310 Chemical Engineering Thermodynamics I (4QH)
(formerly 04.811) Winter Quarter, Alternating Years
Classical thermodynamics as a method of approach to the analysis of processes of interest to chemical engineers. A study of phase equilibria involving the various states of matter; prediction and correlation of physical, chemical, and transport properties of gases and liquids; elementary concepts of quantum and statistical mechanics to interpret the empirical properties of classical thermodynamics. Fundamental principles are reviewed to the extent needed. Prep. BS degree in Chemical Engineering.

CHE 3311 Chemical Engineering Thermodynamics I (2QH)
Winter Quarter, As Announced
CHE 3311 and CHE 3312 cover the same material with the same prerequisites as CHE 3310, but in two 2QH courses.

CHE 3312 Chemical Engineering Thermodynamics II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3311. Prep. CHE 3311.

CHE 3320 Separation Processes (4QH)
(formerly 04.978) Spring Quarter, Alternating Years
Calculation and design methods used in processes involving mass transfer. Topics covered include vapor liquid equilibria for binary and multicomponent systems, multicomponent distillation, absorption and extraction. Emphasis is placed on methods and techniques which are common to many separation processes. Prep. BS degree in Chemical Engineering.

CHE 3321 Separation Processes I (2QH)
Winter Quarter, As Announced
CHE 3321 and CHE 3322 cover the same material with the same prerequisites as CHE 3320, but in two 2QH courses.

CHE 3322 Separation Processes II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3321. Prep. CHE 3321.

CHE 3330 Chemical Process Control (4QH)
(formerly 04.829) Fall Quarter, Alternating Years
Review of classical control techniques; state variable representation and analysis of continuous control systems in chemical engineering, including controllability, observability, and stability. Multivariable control problems in chemical engineering; introduction to optimal control. Digital simulation included where appropriate. Prep. Graduate standing in Chemical Engineering or permission.

CHE 3331 Chemical Process Control I (2QH)
Fall Quarter, As Announced
CHE 3331 and CHE 3332 cover the same material with the same prerequisites as CHE 3330, but in two 2QH courses.

CHE 3332 Chemical Process Control II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3331. Prep. CHE 3331.

CHE 3340 Heterogeneous Catalysis (4QH)
(formerly 04.890) Winter Quarter, Alternating Years
Experimental methods required for determining the surface area and pore structure of catalyst carriers are discussed. These structural characteristics are utilized to estimate mass and heat transport rates within porous catalysts in order to determine their effectiveness with respect to chemical reaction. Mechanisms for chemical poisoning of catalysts are also analyzed. Reactions of practical interest are used to illustrate the applications of heterogeneous catalysis to modern chemical processing problems. Prep. BS degree in Chemical Engineering.

CHE 3341 Heterogeneous Catalysis I (2QH)
Winter Quarter, As Announced
CHE 3341 and CHE 3342 cover the same material with the same prerequisites as CHE 3340, but in two 2QH courses.

CHE 3342 Heterogeneous Catalysis II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3341. Prep. CHE 3341.

CHE 3350 Chemical Process Heat Transfer (4QH)
(formerly 04.973) Spring Quarter, Alternating Years
Empirical methods and calculations used to design heat transfer equipment for the chemical process industries. Review of basic heat transfer principles. Shell-and-tube calculations for liquid and/or vapor phase heat transfer. Direct contact and other special heat exchanger applications. Prep. BS degree in Chemical Engineering.

CHE 3351 Chemical Process Heat Transfer I (2QH)
Winter Quarter, As Announced
CHE 3351 and CHE 3352 cover the same material with the same prerequisites as CHE 3350, but in two 2QH courses.

CHE 3352 Chemical Process Heat Transfer II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3351. Prep. CHE 3351.

CHE 3400 Advanced Chemical Engineering Calculations (4QH)
(formerly 04.801) As Announced
Fundamental process principles leading to an understanding of the stoichiometric principles of chemical process plants. The study of complex material and energy balances is undertaken with the view to apply these principles to actual large chemical plant conditions. Prep. BS in degree Chemical Engineering including differential equations.

CHE 3401 Advanced Chemical Engineering Calculations I (2QH)
As Announced
CHE 3401 and CHE 3402 cover the same material with the same prerequisites as CHE 3400, but in two 2QH courses.

CHE 3402 Advanced Chemical Engineering Calculations II (2QH)
As Announced
Continuation of CHE 3401. Prep. CHE 3401.

CHE 3410 Numerical Techniques in Chemical Engineering (4QH)
(formerly 04.803) Fall Quarter, As Announced
Digital computer applications to chemical engineering problems. Topics covered include location of roots of linear and nonlinear equations, numerical integration, and curve-fitting techniques with emphasis on the numerical solution of ordinary and partial differential equations and to the subject of linear algebra. Prep. BS degree in Chemical Engineering.

CHE 3411 Numerical Techniques in Chemical Engineering I (2QH)
Fall Quarter, As Announced
CHE 3411 and CHE 3412 cover the same material with the same prerequisites as CHE 3410, but in two 2QH courses.

CHE 3412 Numerical Techniques in Chemical Engineering II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3411. Prep. CHE 3411.

CHE 3432 Chemical Data Estimation (4QH)
(formerly 04.832) As Announced
Methods of obtaining physical and thermodynamic properties of chemical compounds and systems without resorting to laboratory investigation. Latest empirical relationships and physical and thermodynamics laws are introduced to obtain data for plant design and other chemical and engineering uses. Prep. BS Degree.

CHE 3450 Analytical and Numerical Techniques (4QH)
(formerly 04.835) As Announced
For students interested in solving comprehensive problems using computer methods. Problems solved in the course will be based on the interest of the students and staff and will be individual. Prep. BS degree and knowledge of digital computer programming.

CHE 3500 Transport Phenomena (4QH)
(formerly 04.823) Winter Quarter, As Announced
Momentum rate conservation equations for steady-state fluid flow in two-dimensional boundary layers are presented and solved to obtain the fluid velocity profiles. These results are utilized in the consideration of heat and mass transfer phenomena at a fluid-solid interface. The development of surface renewal theory is presented and applied to the description of heat and mass transfer phenomena. Prep. BS degree in Chemical Engineering.

CHE 3501 Transport Phenomena I (2QH)
Winter Quarter, As Announced
CHE 3501 and CHE 3502 cover the same material with the same prerequisites as CHE 3500, but in two 2QH courses.

CHE 3502 Transport Phenomena II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3501. Prep. CHE 3501.

CHE 3510 Modeling and Simulation of Chemical Process (4QH)
(formerly 04.837) Winter Quarter, Alternating Years
Use of special purpose and general purpose computer programs in solving the steady-state material and energy balances of chemical processes. Includes related background material which may be applied to these computer programs such as convergence acceleration for calculations involving recycle streams, tearing recycle streams for iteration on minimum number of streams and minimum number of parameters, and algorithms for design variable selection. Prep. Graduate Standing in Chemical Engineering.

CHE 3511 Modeling and Simulation of Chemical Process I (2QH)
Winter Quarter, As Announced
CHE 3511 and CHE 3512 cover the same material with the same prerequisites as CHE 3510, but in two 2QH courses.

CHE 3512 Modeling and Simulation of Chemical Process II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3511. Prep. CHE 3511.

CHE 3520 Computer Process Control (4QH)
(formerly 04.830) Winter Quarter, Alternating Years
Computer control hardware and software. Z-transform, pulse transfer functions, and data holds. Open and closed-loop response and design of sampled-data systems. Computer control algorithms. Digital simulation of sampled data systems. Prep. Graduate standing in Chemical Engineering or permission.

CHE 3521 Computer Process Control I (2QH)
Winter Quarter, As Announced
CHE 3521 and CHE 3522 cover the same material with the same prerequisites as CHE 3520, but in two 2QH courses.

CHE 3522 Computer Process Control II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3521. Prep. CHE 3521.

CHE 3530 Advanced Management Techniques in the Chemical Industry (4QH)
(formerly 04.840) Fall Quarter, Alternating Years
Management techniques applied to the chemical industry. Special attention to management of research organizations and to management of engineering services, such as design, computer, and related activities. Prep. Graduate standing.

CHE 3531 Advanced Management Techniques in the Chemical Industry I (2QH)
Fall Quarter, As Announced
CHE 3531 and CHE 3532 cover the same material with the same prerequisites as CHE 3530, but in two 2QH courses.

CHE 3532 Advanced Management Techniques in the Chemical Industry II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3531. Prep. CHE 3531.

CHE 3540 Advanced Process Design Concepts (4QH)
(formerly 04.845) Spring Quarter, Alternating Years
Techniques and approaches used in the development of new or improved processes. Topics include establishment of process bases, use of process simulators in design, optimization and evaluation of alternatives, and preliminary equipment design and cost estimating techniques. Prep. BS degree in Chemical Engineering.

CHE 3541 Advanced Process Design Concepts I (2QH)
Fall Quarter, As Announced
CHE 3541 and CHE 3542 cover the same material with the same prerequisites as CHE 3540, but in two 2QH courses.

CHE 3542 Advanced Process Design Concepts II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3541. Prep. CHE 3541.

CHE 3543 Advanced Plant Design Concepts (2QH)
Spring Quarter, As Announced
Modern approaches to plant design: computer-oriented design, analysis and simulation of chemical processes, use of strategy decision making in design, advanced scheduling and planning techniques. Prep. BS degree in Chemical Engineering.

CHE 3560 Fluid Mechanics (4QH)
(formerly 04.974) Fall Quarter, Alternating Years
Discussion of statics, kinematics, and stress concepts associated with fluids. Formation of the general equations of motion with application to laminar and turbulent flow. Topics on boundary layer theory and compressible flow are included. Prep. BS degree in Chemical Engineering.

CHE 3561 Fluid Mechanics I (2QH)
Fall Quarter, As Announced
CHE 3561 and CHE 3562 cover the same material with the same prerequisites as CHE 3560, but in two 2QH courses.

CHE 3562 Fluid Mechanics II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3561. Prep. CHE 3561.

CHE 3600 Polymer Science (4QH)
(formerly 04.870) Fall Quarter, Alternating Years
Basic concepts of polymers, thermodynamics of polymer solutions and measurement of molecular weight. Physical and chemical testing of polymers. Crystallinity in polymers and rheology of polymers. Physical and chemical properties of polymers. Mechanisms and conditions for polymerization of polymers including step-reaction, addition and copolymerization. Discussion of carbon-chain polymers, fibers and fiber technology. Prep. BS degree in Chemical Engineering or Chemistry.

CHE 3601 Polymer Science I (2QH)
Fall Quarter, As Announced
CHE 3601 and CHE 3602 cover the same material with the same prerequisites as CHE 3600, but in two 2QH courses.

CHE 3602 Polymer Science II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3601. Prep. CHE 3601.

CHE 3620 Principles of Polymerization (4QH)
(formerly 04.872) Fall Quarter, Alternating Years
Introduction to polymers and polymer properties. Mechanisms of polymerization including step polymerization, radical-chain polymerization, emulsion polymerization, ionic-chain polymerization, chain copolymerization and ring-opening polymerization. Stereo chemistry of polymerization and synthetic reactions of polymers. Applications to reactor design of industrially important polymers. Prep. Graduate Standing in Chemical Engineering.

CHE 3621 Principles of Polymerization I (2QH)
Fall Quarter, As Announced
CHE 3621 and CHE 3622 cover the same material with the same prerequisites as CHE 3620, but in two 2QH courses.

CHE 3622 Principles of Polymerization II (2QH)
Winter Quarter, As Announced
Continuation of CHE 3621. Prep. CHE 3621.

CHE 3630 Chemical Process Pollution Control (4QH)
(formerly 04.850) Spring Quarter, Alternating Years
The basic fundamentals for handling environmental problems in the chemical process industries. Water quality requirements and industrial waste characteristics; wastewater treatment processes applicable to environmental engineering; biological treatment processes and equipment; comprehensive design problems involving biological and tertiary treatment; the economics of water treatment and reuse. Prep. Graduate standing in Chemical Engineering.

CHE 3631 Chemical Process Pollution Control I (2QH)
Winter Quarter, As Announced
CHE 3631 and CHE 3632 cover the same material with the same prerequisites as CHE 3630, but in two 2QH courses.

CHE 3632 Chemical Process Pollution Control II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3631. Prep. CHE 3631.

CHE 3660 Solar Energy Thermal Processes (2QH)
(formerly 04.862) Fall Quarter
Fundamental thermal processes involved in obtaining useful heat from flat-plate solar collectors. The components required in an active solar energy collection system are analyzed and the economics of the system are considered. Prep. BS degree.

CHE 3663 Fundamentals of Polymer Processing (4QH)
(formerly 04.871) Winter Quarter, Alternating Years
Transport properties of polymer solutions and polymer melts. Modeling and design of polymer processing equipment. Flow models for processes involving heat, mass, and/or momentum transfer. Analysis of flow stability and elastic phenomena. Applications to the design of equipment for extrusion, calendering, coating, fiber spinning, tubular film blowing, injection molding and mixing. Prep. Graduate Standing in Chemical Engineering.

CHE 3664 Fundamentals of Polymer Processing I (2QH)
Winter Quarter, As Announced
CHE 3664 and CHE 3665 cover the same material with the same prerequisites as CHE 3663, but in two 2QH courses.

CHE 3665 Fundamentals of Polymer Processing II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3664. Prep. CHE 3664.

CHE 3670 Special Topics in Chemical Engineering (4QH)
(formerly 04.899) As Announced
Topics of interest to the staff member conducting this class are presented for advanced study. A student may not take more than one Special Topics course with any one instructor. Prep. Permission of department staff.

CHE 3671 Kinetics of Chemical Processes (4QH)
(formerly 04.891) Spring Quarter, Alternating Years
The theoretical foundations for the analysis of elementary chemical reaction rates, such as collision theory, particle dynamics, and transition state theory are presented. Consideration is given to the theory of monomolecular reactions and the effect of solvent and electrostatic forces on liquid phase reaction rates. Homogeneous catalysis and selected free-energy correlations are covered. Prep. BS degree in Chemical Engineering.

CHE 3672 Kinetics of Chemical Processes I (2QH)
Winter Quarter, As Announced
CHE 3672 and CHE 3673 cover the same material with the same prerequisites as CHE 3671, but in two 2QH courses.

CHE 3673 Kinetics of Chemical Processes II (2QH)
Spring Quarter, As Announced
Continuation of CHE 3672. Prep. CHE 3672.

CHE 3680 Corrosion Fundamentals (2QH)
(formerly 04.821) As Announced
Economic factors, basic theories, types, behaviors of specific systems, and protection against corrosion are studied. Wherever possible, engineering applications of the principles are emphasized. Prep. BS degree.

CHE 3691 Seminar (2QH)
(formerly 04.990) Any Quarter
Topics of an advanced nature are presented by staff, outside speakers, and students in the graduate program. This course must be attended by all master's degree candidates. Prep. Graduate Standing in Chemical Engineering.

CHE 3701 Special Topics in Chemical Engineering I (2QH)
Any Quarter
Topics of interest to the staff member are presented for advanced study. A student may take this course and its continuation in CHE 3702 with the same instructor.

CHE 3702 Special Topics in Chemical Engineering II (2QH)
A continuation of CHE 3701

CHE 3796 DEng Continuation (0QH)
Any Quarter

CHE 3798 Masters Continuation (0QH)
(formerly 04.9X1) Any Quarter

CHE 3799 PhD Continuation (0QH)
(formerly 04.9X4) Any Quarter

CHE 3860 Thesis (Master's Degree) (10QH)
(formerly 04.991) Any Quarter
Analytical and/or experimental work conducted under the supervision of the department. 10 QH maximum credit for thesis. Students normally register in CHE 3861 or CHE 3862. Prep. Graduate Standing in Chemical Engineering.

CHE 3861 Thesis (Master's Degree) (4QH) Any Quarter

CHE 3862 Thesis (Master's Degree) (2QH) Any Quarter

CHE 3880 Thesis (PhD Degree) (0QH)
(formerly 04.995) Any Quarter
Theoretical and experimental work conducted under the supervision of the department. Prep. Admission to doctoral program in Chemical Engineering.

CHE 3885 Thesis (DEng Degree) (0QH)
(formerly 04.996) Any Quarter
Theoretical and experimental work conducted under the supervision of the department. Prep. Admission to program in Chemical Engineering.

DEPARTMENT OF CIVIL ENGINEERING

The Department of Civil Engineering offers degree programs in construction management, environmental, geotechnical, structures and materials, and transportation engineering on the Master of Science and PhD levels.

The Master of Science degree requirements may be completed on a full-time, part-time or co-operative plan basis. Students have the opportunity to select courses from both the day and evening offerings, but an appropriate sequence of courses must be chosen and approved by the Department. It is essential that each student meet with his/her faculty advisor early in the program so that an appropriate sequence of courses may be arranged.

Master of Science Degree Requirements

A minimum of forty quarter hours of credit including four quarter hours for a Master of Science report or eight quarter hours for a Master of Science thesis with a minimum overall grade point average of 3.0 is required in all programs. With the approval of the department, graduate courses in other departments may be substituted for certain courses. Please refer to the regulations of the Graduate School of Engineering for information on academic and administrative policies.

Students holding a BSCE degree who successfully complete program requirements will receive a Master of Science in Civil Engineering. An unspecified Master of Science degree will be awarded to those students who do not hold a BSCE.

Construction Management

The Construction Management program consists of required core courses primarily from the Civil Engineering Department, complemented by electives from Civil Engineering, the Department of Industrial Engineering and Information Systems, or from the Graduate School of Business Administration. Based on proven proficiency in given areas, certain required core courses may be waived and replaced with alternative courses. In addition to the required core, students choose one or a combination of the following program options: construction and engineering, systems engineering, and/or business management. Each student is required to prepare a program of study which must be reviewed and approved by a faculty advisor during initial registration. Courses taken in other colleges may have different credit hours; degree credit for those courses is granted on a course-for-course equivalency. Also, graduate courses not currently listed as technical electives could be approved as technical electives by the student's advisor, provided that they are consistent with the student's program.

Course Requirements	With Report	With Thesis
Required Core Courses	29 QH	29 QH
Master of Science Report or Thesis	4 QH	8 QH
Four Elective Courses	8 QH (minimum)	
Two Elective Courses		4 QH (minimum)
Minimum Quarter Hours Required*	41 QH	41 QH

*exclusive of any preparatory courses

Required Core Courses Credits

CIV 3131,3132 Statistics I & II.....2 each
CIV 3134 Decision Analysis in Civil Engineering.....2
CIV 3161 Systems Analysis I.....2
CIV 3231,3232 Construction Management I & II.....2 each
CIV 3241,3242 Legal Aspects of Civil Eng'g I & II.....2 each
CIV 3245 Construction Seminar.....2
CIV 3250 Construction Project Evaluation and Financing.....2
CIV 3252 Construction Project Organization and Control.....2
ACC 3301 Financial & Managerial Accounting.....3
or ACC 3811 Financial Accounting.....3
IIS 3615 Analysis & Design of Information Systems.....4
Master of Science Report CIV 3850.....4
or
Master of Science Thesis CIV 3860.....8

The remaining 8 or 4 quarter hours of elective coursework is to be selected from the following:

Construction and Engineering Emphasis

CIV 3136 Performance and Safety Evaluation in Civil Engineering....2
CIV 3237,3238 Construction Methods and Equipment I and II.....2 each
CIV 3410 Soil Mechanics I.....2
CIV 3423(3420,3421) Foundation Engineering I and II.....4
CIV 3520 Concrete Materials: Science & Technology.....2
CIV 3559 Behavior of Reinforce Concrete Structures.....2
CIV 3570 Advanced Steel Design.....2

Business Management Emphasis

HRM 3301 Organizational Behavior.....3
HRM 3972 Labor Relations.....3
FIN 3301 Financial Analysis.....2
MKT 3301 Marketing.....3
IIS 3200 Organizational Perspectives & Project Management.....4
IIS 3204 Engineering/Organizational Psychology.....4
IIS 3208,3209 Financial Management I & II.....2 each

System Engineering Emphasis

CIV 3162 Systems Analysis II.....2
IIS 3106 Elements of Structured Programming.....2
IIS 3218 Planning & Managing Information Systems Development.....4
IIS 3308 Micro-Computer Applications.....2
IIS 3503 Simulation Methodology & Applications.....4
IIS 3604 Data Structures & Database Management.....4
IIS 3621 Information Systems & Society.....2
IIS 3622 Information Systems in a Micro-computer Environment.....4
IIS 3628 Database Management Systems.....4
MSC 3301 Operations.....2
MSC 3928 Decision Support Systems.....3

Environmental Engineering

The Graduate Program in Environmental Engineering consists of required core courses and elective courses as described below. With the approval of the faculty advisor, students may take other graduate courses in civil engineering, in other engineering disciplines, or in other colleges at Northeastern. Courses carrying four quarter hours of credit meet during the day and are open to all students in the environmental engineering program.

Course Requirements	With Report	With Thesis
Required Core Courses	20 QH	20 QH
Master of Science Report or Thesis	4 QH	8 QH
Elective Courses	16 QH	12 QH
Minimum Quarter Hours Required*	40 QH	40 QH

*exclusive of any preparatory courses

Required Core Courses (2 QH equivalents are in parentheses)	Credits
CIV 3312 (3310,3311) Environmental Chemistry I & II	4
CIV 3318 (3315,3316) Water & Wastewater Treatment I&II	4
CIV 3321 (3322, 3323) Environmental Biological Proc. I & II	4
CIV 3327 (3325,3326) Environmental Laboratory	4
CIV 3331 Environmental Computer Applications I & II	2 each

Master of Science Report CIV 3850	4
or	
Master of Science Thesis CIV 3860	8

The remaining 16 or 12 quarter hours of elective coursework is to be selected from two elective groupings, environmental engineering and environmental science with the approval of the student's academic advisor. Normally, not more that four quarter hours of elective courses will be permitted outside of the two categories.

Environmental Engineering

CIV 3317 Advanced Wastewater Treatment	2
CIV 3341 Industrial Waste Disposal	2
CIV 3343,3344 Process Lab in Environmental Engineering I & II	2
CIV 3348 Stream Sanitation	2
CIV 3352 Open Channel Flow	2
CIV 3355 Hyrdrology I	2
CIV 3356 Hyrdrology II	2
CIV 3358 Flow Through Porous Media	2
CIV 3360 Groundwater & Seepage	2
CIV 3367 Water Resources Planning	2
CIV 3370 Air Pollution Engineering	2

Environmental Science

CIV 3372 Air Sampling and Analysis	2
CIV 3374 Air Pollution Science	2
CIV 3376 Industrial Hygiene	2
CIV 3378 Environmental Planning & Management	2
CIV 3380 Environmental Protection	2
CIV 3384 Solid Waste Management	2
CIV 3386 Hazardous Waste Management	2

Geotechnical Engineering

The Geotechnical Engineering program includes study in the areas of soil and rock mechanics, foundation engineering, soil dynamics, earthquake engineering, and experimental soil mechanics. With advisor approval, elective courses may be taken from graduate offerings in either engineering or science for which the student has the necessary prerequisites. The program as shown below is currently under review and will probably be revised in the 88-89 academic year. It is therefore essential that each student meet with his/her academic advisor at the beginning of his/her program to select an appropriate sequence of courses. Courses carrying four quarter hours of credit meet during the day and are open to all students in the geotechnical engineering program.

Course Requirements	With Report	With Thesis
Required Core Courses	18 QH	18 QH
Master of Science Report or Thesis	4 QH	8 QH
Elective Courses	18 QH	14 QH
Minimum Quarter Hours Required*	40 QH	40 QH

*exclusive of any preparatory courses

Required Core Course Selections (2 QH equivalents are in parentheses)Credits

CIV 3131 Statistics I.....2
CIV 3136 Performance and Safety Eval. in Civil Engineering.....2
CIV 3413 (3410,3411) Soil Mechanics I & II.....4
CIV 3412 Stability and Seepage.....2
CIV 3423 (3420,3421) Foundation Engineering I & II.....4
CIV 3470 Introduction to Structural and Soil Dynamics.....2
CIV 3450 Engineering Geology.....2

Master of Science Report CIV 3850.....4
or
Master of Science Thesis CIV 3860.....8

Elective Courses

CIV 3132 Statistics II.....2
CIV 3134 Decision Analysis.....2
CIV 3141,3142 Numerical Methods in Civil Engineering I & II.....2 each
CIV 3161 Systems Analysis I.....2
CIV 3237,3238 Construction Methods and Equipment I & II.....2 each
CIV 3360 Groundwater and Seepage.....2
*CIV 3422 Foundation Engineering.....2
CIV 3430 Soil-Structure Interaction.....4
CIV 3440 Experimental Soil Mechanics.....4
CIV 3471 Advanced Soil Dynamics.....2
CIV 3480 Seismic Design.....2
CIV 3485 Earthquake Engineering.....2
CIV 3510,3511 Advanced Structural Mechanics I & II.....2 each
CIV 3530 Finite Element Analysis of Structures.....2
CIV 3545 Structural Dynamics.....4
CIV 3550 Finite Element Procedures in Engineering Analysis.....4
CIV 3580 Computer-Aided Structural Design.....4

*Not acceptable elective for students who take 4QH course CIV 3423.

Structures and Materials

The Structures and Materials program includes courses in the areas of structural mechanics, structural analysis and design, dynamics of structures and properties of solid materials.

Twenty -eight credit hours (24 in the Thesis option) must be taken from the list of core courses shown below. Other courses can be selected from any Civil Engineering graduate course offering. Each student must meet with his or her advisor in the first quarter of study to obtain advice and approval on a program that is best fitted to his/her interests and objectives.

Both the Master of Science and the Master of Science in Civil Engineering are awarded after the completion of 40 credit hours of work and the satisfactory approval of the Masters Thesis/Report in an oral presentation.

Course Requirements	With Report	With Thesis
Required Core Courses	28 QH	24 QH
Master of Science Report or Thesis	4 QH	8 QH
Elective Courses	8 QH	8 QH ***
Minimum Quarter Hours Required*	40 QH	40 QH

*exclusive of any preparatory courses

Core Course Selections	Credits
CIV 3131,3132 Statistics I & II	2 each
CIV 3136 Performance and Safety Eval. in Civil Engineering	2
CIV 3141 Numerical Methods in Civil Engineering I	2
CIV 3410 Soil Mechanics I	2
CIV 3420 Foundation Engineering I	2
CIV 3470 Introduction to Dynamics & Earthquake Engineering	2
CIV 3480 Seismic Design	2
CIV 3510,3511 Advanced Structural Mechanics I & II	2 each
CIV 3520 Concrete Materials: Science & Technology	2
CIV 3521 Fracture & Fatigue	2
CIV 3522 Nondestructive Testing	?
CIV 3525 Stability	2
CIV 3530 Finite Element Analysis of Structures	2
CIV 3535 Advanced Structural Analysis	2
CIV 3545 Advanced Structural Dynamics	2
CIV 3559 Behavior of Reinforced Concrete Structures	2
CIV 3560 Prestressed Concrete	2
CIV 3561 Reinforced Concrete Slabs	2
CIV 3570 Advanced Steel Design	2
CIV 3571 Inelastic Steel Design	2
CIV 3575 Bridge Design	2
Master of Science Report CIV 3850	4
or	
Master of Science Thesis CIV 3860	8
Elective Courses	
Selected from engineering or science	4 or 8

*** These credits can also be selected from the list shown above.

Transportation Engineering

The Transportation Engineering Program is designed for students with career goals in transportation engineering, planning or research. This program may consist of courses from engineering, liberal arts, and/or business. In addition to the degree requirements stated at the beginning of the civil engineering section, students who do not meet a minimum twenty-four quarter hours in civil engineering courses will receive an unspecified Master of Science degree. With advisor approval, a maximum of three courses may be taken in non-technical fields (arts and sciences or business administration). Students should consult the appropriate catalogs for courses outside of engineering.

Course Requirements	With Report	With Thesis
Required Core Courses	12 QH	12 QH
Master of Science Report or Thesis	4 QH	8 QH
Technical Courses	18-24 QH	14-20 QH
Non-Technical Courses	0-6 QH	0-6 QH
Minimum Quarter Hours Required*	40 QH	40 QH

*exclusive of any preparatory courses

Required Core Courses	Credits
CIV 3131,3132 Engineering Statistics I & II	2 each
CIV 3161,3162 Systems Analysis I & II	2 each
CIV 3640,3641 Theory & Practice of Transportation Planning I & II	2 each
Master of Science Report CIV 3850	4
or	
Master of Science Thesis CIV 3860	8
Technical Courses	
CIV 3134 Decision Analysis	2
CIV 3163 Systems Analysis III	2
CIV 3610 Urban Public Transportation	2
CIV 3630 Traffic Engineering	2
CIV 3635 Transportation Engineering	2
CIV 3650,3651 Urban Transportation Analysis I & II	2 each
IIS 3514 Advanced Operations Research	4
IIS 3503 Simulation Methodology & Applications	4
IIS 3512 Queuing Theory & Its Applications	2
IIS 3614 Basic Information System Technology	2
IIS 3615 Analysis and Design of Computer Information Systems	4
Non-Technical Courses (count as 2 credits each when determining QH for degree)	
ECN 3363 Urban Economic Systems	3
ECN 3364 Urban Economic Development	3
ECN 3365 Economics of Urban Transportation	3
ECN 3366 Economics of Inter-City Transportation	3
ECN 3371 Regional Development	3
ECN 3379 Development Planning Seminar	3
POL 3618 Problems in Urban Planning	3
POL 3619 Techniques of Urban Planning	3
POL 3623 Transportation Policy	3
TRN 3901 Transportation Policy & Regulation	3

The Doctor of Philosophy Degree

Award of the Doctor of Philosophy degree is based on exceptional performance in course work and evidence of ability to formulate and execute original research. The degree program has two components: (1) An academic program consisting of a set of graduate level courses which provide depth in a specific area of Civil Engineering (the major field) and additional exposure, at an advanced level, to one or more science disciplines (the minor field); and (2) the doctoral dissertation, an extended independent research effort on a relevant technical problem resulting in an original contribution.

Mastery of the subject matter is measured by a qualifying examination covering a subset of subjects selected from the major field. Research progress is monitored periodically by a Doctoral Dissertation Committee and the candidate is required to present and defend the research results before an expanded group of faculty and research staff at the completion of the work.

The doctoral program is deliberately designed to be flexible with respect to subject area since the PhD degree is primarily a "research" degree and therefore the program must be adaptable to changes in research needs.

Qualifying Examination and Degree Candidacy

The qualifying examination will consist of written and oral portions and its content will depend on the educational background and objectives of the student. In general, the written part will cover subject matter at the Masters level selected from the major field and will include: (1) basic engineering and science disciplines, and (2) civil engineering application areas. The oral portion will measure general comprehension and aptitude for research. If the examination is failed, it may be repeated with permission of the PhD Committee. The qualifying examination must be taken no later than two years after admittance as a doctoral student. Upon successful completion of the examination and satisfaction of the general graduate school regulations, the student is classified as a doctoral candidate. Doctoral study must be completed within five years after classification as a doctoral degree candidate.

Course Requirements

A proposal defining the content of the academic program is developed jointly by the student and faculty advisor, and then reviewed by the PhD Committee. Intellectual rigor, connectivity of subject matter, and compatibility with departmental interests are critical issues. Final approval is arrived at through discussion and represents a mutual agreement between the student and the PhD Committee. Flexibility in program definition is encouraged, especially in areas where complementary courses exist in other departments, or where expertise resides outside the Department and the objective is to introduce new technology in civil engineering practice.

The academic program must contain at least 72 quarter hours of graduate level course work, exclusive of seminars, special study research activities, and MS thesis and PhD dissertation work. A minimum of 60 quarter hours must be related to the major field but can include courses from other departments when appropriate. The minor field must include a minimum of 12 quarter hours of course work in science disciplines of interest to civil engineers, e.g., mathematics, computer science, material science, earth sciences, chemistry, biology, health sciences.

Transfer credit for students entering with a Master of Science Degree will be handled on an individual basis. A minimum of 28 QH of coursework beyond the MS degree must be completed at Northeastern.

Language Requirement

The candidate must be proficient in technical writing and oral presentation in the English language. Appropriate course work may be required by the PhD Committee.

Residence Requirement

Three successive quarters of full-time study on campus are required to establish residence. The total effort for a doctorate involves, as a minimum, three years of full-time work beyond the Bachelor's Degree. Candidates who enter the doctoral program with a Master of Science Degree may complete the requirements in less time, but they should anticipate at least two years of full-time effort.

Dissertation

Once degree candidacy has been established, the student is allowed to proceed with the dissertation effort. The candidate is required to generate a dissertation proposal and identify a civil engineering faculty member who will act as the dissertation advisor. A Dissertation Committee, consisting of the dissertation advisor and at least four other Northeastern faculty members, selected by the PhD Committee, will monitor progress and approve the final document.

Comprehensive Examination

The comprehensive examination consists of a defense of the doctoral research work and an examination of subject matter related to the dissertation area.

Faculty

Mishac K. Yegian, Chairman

Professors

Amory, Reginald L.,PE, PhD, Rennselaer Polytechnic Institute; advanced structural mechanics, structural stability, finite element analysis, complex steel structures, inelastic and viscoelastic behavior of materials

Blanc, Frederic C., PE, PhD, New York University; wastewater; industrial, hazard, and solid waste

Cochrane, John J., PE, PhD, Rennselaer Polytechnic Institute; treatment process design, computer-aided analysis and design, water quality management

Gregory, Constantine J., PhD, Rutgers University; air pollution control, environmental modeling, industrial hygiene

Leet, Kenneth M., PE, ScD, Massachusetts Institute of Technology; design and behavior of reinforced and prestressed concrete structures, high strength concrete, durability of concrete

Yegian, Mishac K., PE, PhD, Massachusetts Institute of Technology; soil dynamics, earthquake engineering, risk analysis

Associate Professors

Furth, Peter G., PhD, Massachusetts Institute of Technology; transportation analysis and planning

Jaworski, Walter E., PE, PhD, Massachusetts Institute of Technology; earth structures, foundation engineering

Kupferman, Michael, PE, PhD, University of Massachusetts; engineering geology, geotechnology

Meserve, Robert L., PE, MS, Northeastern University; water and wastewater treatment, hydraulics, highways, surveying, environmental design

Schoon, John G., PE, PhD, Polytechnic Institute of New York; transportation analysis and planning, traffic engineering, highways and public works

Scranton, Richard J., MS, Massachusetts Institute of Technology; transportation systems, mechanics, applied probability

Wei, Irvine W., PhD, Harvard University; water chemistry, treatment processes, acid precipitation

Assistant Professors

Bernal, P. Dionisio, PhD, University of Tennessee; earthquake engineering, structural engineering

Hadley, Peter K., PhD, Princeton University; computer aided engineering, earthquake engineering

Karaa, Fadi A., PhD, Massachusetts Institute of Technology; construction management

Marciano, Eugene A., PhD, Purdue University; geotechnical engineering, soil dynamics, earthquake engineering, reliability analysis

Najjar, Walid, PhD, Cornell University; engineering properties of materials, concrete design

Touran, Ali, PhD, Stanford University; construction engineering and management

Uang, Chia-Ming, PhD, UC, Berkeley; steel design, seismic design, experimental investigation of structures

Advisors

	Part-time		Full-time	
Construction	(A-K)	Prof. Karaa	(A-Z)	Prof. Karaa
	(L-Z)	Prof. Touran		
Environmental	(A-E)	Prof. Gregory	(A-Z)	Prof. Meserve
	(F-J)	Prof. Blanc		
	(K-P)	Prof. Cochrane		
	(Q-Z)	Prof. Wei		
Geotechnical	(A-L)	Prof. Kupferman	(A-L)	Prof. Kupferman
	(M-Z)	Prof. Marciano	(M-Z)	Prof. Marciano
Structural	(A-L)	Prof. Hadley	(A-Z)	Prof. Bernal
	(M-Z)	Prof. Leet		
Transportation	(A-L)	Prof. Schoon	(A-L)	Prof. Schoon
	(M-Z)	Prof. Furth	(M-Z)	Prof. Furth

CIVIL ENGINEERING

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; however, the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine what courses are actually offered in any given quarter and at what day and time.

CIV 3131 Engineering Statistics I (2QH)
(formerly 01.916) Fall Quarter
The basic elements of probability theory and statistics and their use via the solution of various civil engineering problems encountered in fluid mechanics, construction management, structures, transportation. Probability of events, random variables and distributions, derived distributions, expectation, common probability models. Prep. Undergraduate calculus.

CIV 3132 Engineering Statistics II (2QH)
(formerly 01.917) Winter Quarter
Continuation of CIV 3131. Includes parameter estimation, confidence intervals, hypothesis testing, and linear statistical models. Prep. CIV 3131.

CIV 3134 Decision Analysis in Civil Engineering (2QH)
Spring Quarter
Basic theory of decision-making under uncertainty, applied to design and managerial problems in civil engineering, feasibility analysis and construction (e.g. reservoir capacity design, dam safety options, to build or not to build a drainage system, flood levee design, economic analysis of construction projects, value engineering, construction method selection in tunneling). Decision trees, value of perfect information and value of sample information. Multi-criteria decision making and multi-attribute utility theory. Prep. CIV 3131

CIV 3136 Performance and Safety Evaluation in Civil Engineering (2QH)
Spring Quarter
Application of reliability to the design and analysis of civil engineering facilities. The reliability of redundant systems such as indeterminate structures. Statistical distributions of system parameters (e.g. component strengths, flow rates, soil strengths) and demands (e.g. seismic loading, traffic volumes). Safety indices, load factors, and reliability based design codes. Damage evaluation and reliability prediction of civil engineering facilities. Prep. CIV 3131

CIV 3141 Numerical Methods in Civil Engineering I (2QH)
(formerly 01.888) Fall Quarter
Introduction, errors in numerical analysis. Solution of nonlinear algebraic equations. Solution of large systems of linear algebraic equations by direct and iterative methods. Introduction to matrix eigenvalue problems. Examples are drawn from structural mechanics. Prep. Admission to the Graduate School of Engineering.

CIV 3142 Numerical Methods in Civil Engineering II (2QH)
(formerly 01.889) Winter Quarter
Continuation of CIV 3141. Approximation of functions: interpolation, and least squares curve fitting; orthogonal polynomials. Numerical differentiation and integration. Solution of ordinary and partial differential equations, and integral equations; discrete methods of solution of initial and boundary-value problems. Examples are drawn form structural mechanics, geotechnical engineering, hydrology and hydraulics. Prep. CIV 3141.

CIV 3161 Systems Analysis I (2QH)
(formerly 01.807) Fall Quarter
Application of linear optimization models to various civil engineering problems: the simplex method, sensitivity analysis, transportation problem, transhipment problem, shortest path problem. Prep. Admission to Graduate School of Engineering.

CIV 3162 Systems Analysis II (2QH)
(formerly 01.808) Winter Quarter
Further application of systems analysis techniques to civil engineering problems: dynamic programming, linear regression, model estimation, queueing theory, project evaluation. Prep. CIV 3161 and CIV 3131; to be taken concurrently with CIV 3132.

CIV 3171 Seminar in Public Works I (2QH)
Winter Quarter
History and role of Public Works in development (topics include historical development, economic and financial dimensions of public works in city and state government, technological change, local, regional and national planning); Public Works capital development (topics include political, economic, financial, social, administrative and technical factors). Prep. Admission to Graduate School of Engineering

CIV 3172 Seminar in Public Works II (2QH)
Spring Quarter
Public Works applications in management science (topics include applications of benefit/cost, cost-effectiveness, allocation models, decision theory, queueing theory, simulation, etc.); Maintenance management (topics include inventory, performance standards, scheduling, budgets and finance); Public Works planning issues (topics include environmental assessment, techniques of land use planning and procedures, facility location and resource utilization. Prep. CIV 3171

CIV 3231 Construction Management I (2QH)
(formerly 01.821) Fall Quarter
A presentation of all aspects of construction cost estimating; contracts, labor, equipment, material and indirect costs, conceptual estimating, detailed estimating and bid preparation, computerized cost estimating. Students will work on a cost estimating projects as part of requirements. Prep. Admission to Graduate School of Engineering

CIV 3232 Construction Management II (2QH)
(formerly 01.822) Winter Quarter
Construction planning and scheduling with an emphasis on network-based scheduling systems, e.g. CPM and Procedure diagramming, resource leveling and allocation, time-cost trade off, PERT statistical approach, and introduction to network based project control. Prep. Admission to Graduate School of Engineering

CIV 3237 Construction Methods and Equipment I (2QH)
(formerly 01.830) Fall Quarter
Selection and application of construction equipment; earthmoving equipment including excavators, bulldozers, scrapers, etc.; productivity analysis of equipment operations, construction equipment economics. Prep. Admission to Graduate School of Engineering.

CIV 3238 Construction Methods and Equipment II (2QH)
(formerly 01.831) Winter Quarter
Continuation of CIV 3237; Equipment production systems including truck-loader, scraper-tractor, belt-conveyer systems, etc., bituminous pavements' material and equipment, asphalt plants. Prep. CIV 3237.

CIV 3241 Legal Aspects of Civil Engineering I (2QH)
(formerly 01.832) Fall Quarter
A presentation of U.S. and International legal systems and theories necessary for the comprehension of business and contractual liabilities, rights and obligations in the engineering field. Prep. Admission to the Graduate School of Engineering.

CIV 3242 Legal Aspects of Civil Engineering II (2QH)
(formerly 01.833) Winter Quarter
Description and evaluation of various types of construction contracts, procedures and formats for submitting bids, filing claims, and legal steps to avoid liabilities, utilizing the principles learned in CIV 3241. Prep. CIV 3241.

CIV 3245 Construction Seminar (2QH)
(formerly 01.827) Spring Quarter
A reading and discussion course centering on recent research publications in Construction Engineering. Prep. Limited to Construction Management Program majors; to be taken in Final Spring Quarter.

CIV 3250 Project Evaluation and Financing (2QH)
Fall Quarter
Review of project evaluation techniques, as applied to construction and infrastructure projects. Bond pricing mortgage analysis. Construction loan analysis in the development process. Valuation of income-producing properties. Project financing packages in the areas of real property and infrastructure. Impact of financing on project value. Capital Budgeting Models and their applications to infrastructure planning. Prep. Concurrent with ACC 3811

CIV 3252 Construction Project Control and Organization (2QH)
Winter Quarter
Organization of construction firms, both at the general corporate level and at the project level. Organization dynamics designed to respond to the requirements of the environment given the internal constraints of the firm. Computer systems for the control of construction projects. Design attributes to fit the needs of the organization and the end users. Estimating, scheduling, budgeting and financial control of projects. Network-based systems for planning and time control. Intra-project and inter-project resource allocation. Data-base design concepts for decision support systems. Prep. CIV 3161

CIV 3310 Environmental Chemistry I (2QH)
(formerly 01.920) Fall Quarter
A review of basic chemistry is followed by a discussion of the chemical kinetics and equilibrium chemistry of homogeneous and heterogeneous systems with applications in environmental engineering. The specific topics to be covered include physical and chemical properties of water, acid-base reactions, pH, alkalinity, equilibrium calculation using analytical and graphical methods, and coordination chemistry. The emphasis is placed on the quantitative evaluation of chemical changes in the environment. Prep. Two quarters of general chemistry.

CIV 3311 Environmental Chemistry II (2QH)
(formerly 01.921) Winter Quarter
A continuation of CIV 3310, including the basic principles of chemical thermodynamics, re precipitation-dissolution reactions, colloid chemistry, adsorption-desorption, redox reactions, and organic chemistry as they relate to environmental problems and engineering. Practical applications in water softening, coagulation, activated-carbon adsorption, and chlorination are discussed as are electrochemical measurements. Prep. CIV 3310; to be taken concurrently with CIV 3325.

CIV 3312 Environmental Chemistry I and II (4QH)
(formerly 01.923) Fall Quarter
Embodies the material in CIV 3310 and CIV 3311. Prep. Two quarters of general chemistry.

CIV 3315 Water and Wastewater Treatment I (2QH)
(formerly 01.910) Fall Quarter
Covers design principles and theory for pretreatment, sedimentation, coagulation, flocculation, chemical softening, filtration, activated carbon adsorption and disinfection. Prep. Undergraduate fluid mechanics.

CIV 3316 Water and Wastewater Treatment II (2QH)
(formerly 01.911) Winter Quarter
A continuation of CIV 3315 including design principles involved in various biological treatment systems, oxygen transfer systems, solids thickening, aerobic digestion and anaerobic treatment systems. Prep. CIV 3315 and CIV 3323.

CIV 3317 Advanced Wastewater Treatment (2QH)

Spring Quarter

This course covers operational and design principles involved in sludge dewatering, biological nitrification and dentrification, phosphorus removal and other advanced treatment methods. Prep. CIV 3316.

CIV 3318 Water and Wastewater Treatment I and II (4QH)
(formerly 01.914) Winter Quarter

Embodies the material in CIV 3315 and CIV 3316. Prep. Undergraduate fluid mechanics.

CIV 3321 Environmental Biological Processes (4QH)

Winter Quarter

Embodies the subject matter of courses CIV 3322 and CIV 3323. Prep. Civ 3311.

CIV 3322 Environmental Biological Processes I (2QH)

Winter Quarter

A study of microbiology with emphasis on biological processes of importance in environmental engineering applications. Includes: cell structure, cell nutrition, morphology, microbial metabolism and kinetics as applied to biological treatment processes. Prep. CIV 3310, may be taken concurrently with CIV 3311.

CIV 3323 Environmental Biological Processes II (2QH)

Spring Quarter

A continuation of CIV 3322, which provides the student with biological wastewater treatment process, theory, eutrophication theory, as well as covering effects of toxins on microorganisms and disinfection theory. Prep. CIV 3322.

CIV 3325 Environmental Chemistry Laboratory (2QH)
(formerly 01.930) Winter Quarter

A laboratory course emphasizing analysis related to important topic areas in environmental chemistry including alkalinity, hardness, acid-base reactions, chemical kinetics, precipitation reactions, chlorine and oxidation-reduction reactions. Prep CIV 3310; (may be taken concurrently with CIV 3311).

CIV 3326 Biological Processes Laboratory (2QH)

Spring Quarter

A laboratory course emphasizing analysis related to microbiological examination and other wastewater treatment parameters used to monitor the biological process such as: BOD, TOC, COD, gravimetric methods and dissolved oxygen. Prep. CIV 3325.

CIV 3327 Environmental Laboratory (4QH)
(formerly 01.933) Fall Quarter

Embodies the material in CIV 3325 and CIV 3326. Prep. to be taken concurrently with CIV 3312.

CIV 3331 Environmental Computer Applications I (2QH)

Fall and Winter Quarters

Utilization of computers for the handling of environmental engineering data. Topics to be covered include: statistics, curve fitting, correlation, linear regression, spreadsheet data handling, BOD kinetics, chemical reaction interactions. Prep. Admission to Graduate School and familiarity with FORTRAN or BASIC.

CIV 3332 Environmental Computer Applications II (2QH)

Spring Quarter

A continuation of CIV 3331, this course covers the application of computer modeling and use of data base management systems to specific environmental problems and processes covering areas such as: reactor kinetics, stream and lake modeling, treatment plant performance modeling and stormwater management. Prep. CIV 3331.

CIV 3341 Industrial Waste Disposal (2QH)
(formerly 01.913) Spring Quarter
Evaluation of industrial waste problems and development of process design for the required treatment facilities; study of various manufacturing processes and their wastewater problems; industrial waste survey techniques; characteristics of industrial wastes; evaluation of hazardous materials; waste reduction methods; physical, chemical, biological and advanced treatment methods; industrial wastewaters and disposal and treatment of industrial solids and liquids. Prep. CIV 3311 and CIV 3317 can be taken concurrently.

CIV 3343 Process Lab in Environmental Engineering I (2QH)
(formerly 01.935) Winter Quarter
Laboratory scale unit operations illustrating the physical, chemical and biological principles involved in water and wastewater treatment. The aim is to obtain criteria for system design. Topics include disinfection, water softening, sedimentation, chemical coagulation, and ion exchange. Prep. CIV 3316 and CIV 3326 or CIV 3318 concurrently.

CIV 3344 Process Lab in Environmental Engineering II (2QH)
(formerly 01.936) Spring Quarter
A continuation of CIV 3343. Topics include biodegradability studies using activated sludge, fixed-film reactors, anaerobic digestion, vacuum filtration, and chemical-physical processes involved in wastewater treatment. A comprehensive evaluation of each unit process is required in a report from each student. Prep. CIV 3343.

CIV 3348 Stream Sanitation (2QH)
(formerly 01.954) Winter Quarter
Analysis of the fate and effects of discharge of conservative and non-conservative pollutants in surface receiving waters and groundwaters. Topics include BOD and oxygen relationships in streams, eutrophication and general water quality improvement techniques. Prep CIV 3310.

CIV 3352 Open Channel Flow (2QH)
(formerly 01.903) Winter Quarter
Rapidly varied flow, hydraulic jump and its applications; flow through nonprismatic channel sections; flow in channels of nonlinear alignment, wave action; unsteady flow, dynamic equations; wave propagation; flood routing in rivers. Prep. Undergraduate Open Channel Flow.

CIV 3355 Hydrology I (2QH)
(formerly 01.908) Winter Quarter, Alternate Years
Elements of the hydrologic cycle, precipitation, evaporation, streamflow, groundwater; water balance equation for watersheds; streamflow hydrographs, unit hydrographs, hydrographs of overland flow; relation between precipitation and runoff; hydrologic and hydraulic routings, linear reservoirs routing. Prep. Undergraduate fluid mechanics and hydraulic engineering.

CIV 3356 Hydrology II (2QH)
(formerly 01.909) Spring Quarter, Alternate Years
Deterministic hydrologic models; probability in hydrology; stochastic hydrology, generation of data, Markov chain series; flood forecasting; applications of hydrology and design considerations. Prep. CIV 3355.

CIV 3358 Flow Through Porous Media (2QH)
(formerly 01.924) Fall Quarter, Alternate Years
Groundwater uses; properties of porous media; infiltration, saturated and unsaturated zones, soil water interactions; types of aquifers; Darcy's law, Dupuit-Forchemier's assumption, groundwater flow equations, steady and unsteady cases; steady state seepage problems, method of flow nets; dispersion of groundwater, quality and contamination of groundwater. Prep. Undergraduate fluid mechanics and hydraulic engineering.

CIV 3360 Groundwater and Seepage (2QH)
(formerly 01.925) Winter Quarter, Alternate Years
Hydraulics of wells, steady and transient flow equations, pumping tests, multiple well systems, methods of images; superposition, leaky aquifers, salt-water intrusion, static equilibrium and hydrodynamic equilibrium, control of saline water intrusion; numerical and experimental methods, physical models, analog models, finite difference solution, introduction to the method of finite elements. Prep. CIV 3358.

CIV 3367 Water Resources Planning (2QH)
(formerly 01.965) Fall Quarter, Alternate Years
The nature of water resources projects (socio-political, legal); water resources planning objectives (economic, cost, benefit); problems in water resources engineering (development, design, operational, recapitulation); introduction to linear and dynamic programming; simulation methods; Case studies. Prep. CIV 3355.

CIV 3370 Air Pollution Engineering (2QH)
(formerly 01.950) Winter Quarter
Theory and practice related to engineering management of air resources; applications of models for the atmospheric dispersion of pollutants; analysis of control systems for gaseous and particulate emissions utilizing dry collection, wet collection, absorption, and catalytic processes. Discussion of source control evaluation and air quality standards. Course CIV 3374 is recommended. Prep. Admission to Graduate School.

CIV 3372 Air Sampling and Analysis (2QH)
(formerly 01.955) Spring Quarter, Alternate Years
A laboratory course on air pollution measurements utilizing physical, chemical and instrumental methods and calibration and use of sampling equipment for gaseous and particulate pollutants. Identification and quantitative measurements of pollutants are performed utilizing microscopy, spectrophotometery, gas chromatography, and atomic absorption spectroscopy. Prep. CIV 3370.

CIV 3374 Air Pollution Science (2QH)
(formerly 01.957) Fall Quarter
Biological and chemical aspects of air pollution with emphasis on the toxicological aspects of the environment, physiological effects of aerosols, analysis of organic and inorganic constituents of the atmosphere and rationale for establishment of air quality criteria and standards. Note: Open to non-engineering as well as to engineering graduate students. Prep. Consent of the department and instructor.

CIV 3376 Industrial Hygiene (2QH)
(formerly 01.952) Winter Quarter
Characterization and control of industrial problems associated with noise, heat and ventilation. Physical and biological aspects of environmental stress are discussed. Emphasis is placed on the application of engineering principles to the design of control systems. Evaluation procedures for control effectiveness are reviewed. Prep. Admission to Graduate School of Engineering.

CIV 3378 Environmental Planning and Management (2QH)
(formerly 01.980) Fall Quarter, Alternate Years
Planning and operation, and management of specific environmental systems, such as collection systems; solids separators, combined systems control, sewer flushing, deposition loadings with least squared applications, and case studies in optimal design of treatment plants with variable input. Prep. Admission to Graduate School of Engineering.

CIV 3380 Environmental Protection (2QH)
(formerly 01.985) Spring Quarter, Alternate Years
Environmental quality and its effects on health, comfort, aesthetics, balance of ecosystems and renewable resources; interaction of the water-land-air complex, vector control, food protection, ionizing radiation, other radiation, and thermal and noise pollution. Prep. Admission to Graduate School of Engineering.

CIV 3384 Solid Waste Management (2QH)
(formerly 01.945) Fall Quarter
Basic solid waste management for engineering and science students covering storage, collection practices, sanitary landfill principles, incineration practices and reclamation possibilities. Prep. Admission to Graduate School of Engineering.

CIV 3386 Hazardous Waste Practices (2QH)
(formerly 01.946) Spring Quarter
An investigation of hazardous waste management practices including: identification, storage, transport, treatment processes, incineration, recycling, reuse, chemical landfills and ground-water contamination. Prep. CIV 3311 or CIV 3312.

CIV 3410 Soil Mechanics I (2QH)
(formerly 01.871) Fall Quarter
Phase relationships and index properties, permeability, capillarity, effective stress concept, porous media flow, stress distribution, stress path concept, 1-D settlement analysis. Prep. Undergraduate course in soil mechanics.

CIV 3411 Soil Mechanics II (2QH)
(formerly 01.872) Winter Quarter
Continuation of CIV 3410. Consolidation theory, 3-D settlement analysis, shear strength properties of soils, stress path analysis. Prep. CIV 3410.

CIV 3412 Stability and Seepage (2QH)
formerly 01.873) Spring Quarter
A continuation of CIV 3411. Stability of open cuts and natural slopes; numerical analysis and computer applications to stability, seepage, consolidation, and deformation problems, laboratory testing; field instrumentation; special topics. Prep. CIV 3411 or CIV 3413

CIV 3413 Soil Mechanics I and II (4QH)
(formerly 01.877) Fall Quarter
Embodies the material in CIV 3410 and CIV 3411. Prep. Undergraduate course in soil mechanics.

CIV 3420 Foundation Engineering I (2QH)
(formerly 01.874) Fall Quarter, Alternate Years
Lateral earth pressure theory; retaining wall design; anchored bulkheads; braced cofferdams, dewatering, observational approach to design. Prep. CIV 3411 or CIV 3413.

CIV 3421 Foundation Engineering II (2QH)
(formerly 01.875) Winter Quarter, Alternate Years
Bearing capacity, design of shallow foundations, site improvement (preloading, deep densification), case studies of foundation performance. Prep. CIV 3420.

CIV 3422 Foundation Engineering III (2QH)
(formerly 01.876) Spring Quarter, Alternate Years
Pile foundations, caissons, selection of foundation scheme; case studies. Prep. CIV 3421.

CIV 3423 Foundation Engineering I and II (4QH)
(formerly 01.878) Spring Quarter
Embodies the course content offered in CIV 3420 and CIV 3421. Prep. CIV 3411 or CIV 3413.

CIV 3430 Soil-Structure Interaction (4QH)
(formerly 01.870) Winter Quarter, Alternate Years
Introduction to pile foundations; beam on elastic foundations; deformations of axially and laterally loaded single piles and pile groups using available computer software; pile load tests; case histories. Prep. CIV 3411 or CIV 3413.

CIV 3440 Experimental Soil Mechanics (4QH)
(formerly 01.879) Spring Quarter, Alternate Years
Laboratory evaluation of engineering properties of soils with emphasis on permeability, compressibility and strength. Introduction to model analysis of static and dynamic behavior of soils. Prep. CIV 3411 or CIV 3413.

CIV 3450 Engineering Geology (2QH)
(formerly (01.882) Winter Quarter
Selected topics in historical and structural geology related to engineering geology; origin and occurrence of various rock types, geologic structures, faulting and joint systems; weathering of rock and weathering products, glaciation, geologic mapping and environmental aspects; case studies. Prep. Undergraduate course in geology.

CIV 3470 Introduction to Structural and Soil Dynamics (2QH)
(formerly 01.886) Fall Quarter
Dynamic response analysis of one-degree-of-freedom systems, characteristics of earthquakes and resulting ground motions, response spectra, stress-strain behavior of soils during dynamic and repeated loading, laboratory and field determinations, wave propagation through elastic media, effect of local soil condition upon earthquake ground motions. Prep. Admission to the Geotechnical Engineering Program.

CIV 3471 Advanced Soil Dynamics (2QH)
(formerly 01.887) Winter Quarter, Alternate Years
Dynamic response analysis of a single mass, multi-degree-of-freedom systems; machine foundation design and analysis; soil-structure interaction, ground vibrations, sources and control; shear strength during repeated loading, liquefaction; dynamic analysis of retaining structures and slopes. Prep. CIV 3470.

CIV 3480 Seismic Design (2QH)
(formerly 01.850) Spring Quarter, Alternate Years
Earthquake considerations in building design process, dynamic analysis of multi-degree-of-freedom elastic systems subjected to earthquake motions and cyclically applied forces, inelastic dynamic response analysis. Seismic provisions of building codes; soil-structure interaction. Prep. CIV 3470.

CIV 3485 Earthquake Engineering (2QH)
(formerly 01.851) Spring Quarter, Alternate Years
Seismic hazard and seismic risk analysis; seismic design decision analysis; lifeline earthquake engineering; pipelines, liquid storage tanks, water distribution systems; earthquake analysis of earth dams and slopes; dynamic analysis of retaining walls and offshore facilities; dynamically loaded piles. Prep. CIV 3470.

CIV 3510 Advanced Structural Mechanics I (2QH)
(formerly 01.841) Fall Quarter
Analysis of force equilibrium (stress), deformation/deplacement (strain), and force/deformation (Hooke's Law) for an elastic solid; compatibility; governing equations for complete and approximate elasticity solution. Plane stress solution for narrow rectangular beams. Torsion, Saint Venant's theory, membrane analogy, rectangular sections, thin open and closed sections. Introduction to bending of thin plates. Prep. Undergraduate structural mechanics and structural analysis.

CIV 3511 Advanced Structural Mechanics II (2QH)
(formerly 01.842) Winter Quarter
Consistent models for the mechanics of simple structural elements: axial, bending, plane stress, and the like. Equilibrium, geometry of deformation, and force/deformation as the governing relations of all structural elements. Work and energy principles: virtual displacement, virtual forces, minimum potential energy, minimum complementary energy, introduction to variational ideas, Rayleigh-Ritz method. Prep. CIV 3510.

CIV 3520 Concrete Materials: Science and Technology (2QH)

Winter Quarter

Chemical, physical and micro-structural properties of hydrated cement. Strength-porosity relationship. Concept of gel/space ratio. Transition zone (cement paste-aggregate interface). Mix design and procedures. Admixtures. Pozzolans. Micro-cracking and the stress-strain curve. Fracture and Failure criteria. Dimensional stability: creep and shrinkage. Durability and permeability: freezing and thawing, sulfate attack, alkali-aggregate reaction, corrosion of reinforcement, surface wear. Deterioration control and prevention. Concretes for special applications: high-strength, shrinkage-compensating, fibre reinforced, others. Testing. Prep. Admission to Graduate School.

CIV 3521 Fracture and Fatigue (2QH)

Spring Quarter, Alternate Years

Fracture and fatigue of materials and structures, with emphasis on steel and concrete. Stress intensity factor. Fracture toughness. Mixed-mode fracture. Linear-elastic versus non-linear fracture-mechanics. Fatigue-crack, initiation and propagation. Stress corrosion cracking. Corrosion fatigue. Fracture criteria. Applications in finite element analysis. Prep. Admission to Graduate School.

CIV 3522 Nondestructive Testing (2QH)

Fall Quarter, Alternate Years

Nondestructive testing (NDT) of structures and materials, with emphasis on concrete and steel. Introduce theory, current technology and practice. These methods include: ultrasonic pulse velocity, pulse echo, acoustic emission, radioactive/nuclear, radiography, surface hardness, penetration resistance, pullout, maturity, among others. Various methods are compared as to accuracy/variability, safety, and cost effectiveness (pros and cons for each method).

CIV 3525 Stability (2QH)

(formerly 01.859) Spring Quarter

Prediction of the buckling loads in columns, behavior of beam-columns, use of numerical methods to compute the buckling loads of nonprismatic members, buckling of plates. Prep. CIV 3510 and CIV 3511.

CIV 3530 Finite Element Analysis of Structures (2QH)

(formerly 01.843) Spring Quarter

Introduction to finite-element method for structural analysis. Overview of direct stiffness method. Formulation of element stiffness matrices by direct use of elasticity relations and by energy methods for simple elements; axial, bending, plane stress, and plane strain; transformation of coordinate systems; lumping work equivalent loads; bounds on the error solution. Plate bending. Use of finite-element computer programs. Prep. CIV 3511.

CIV 3535 Advanced Structural Analysis (2QH)

(formerly 01.845) Winter Quarter

Formulation and solution of structural problems with primary application to member systems (trusses, frames, curved members), matrix formulation of flexibility and stiffness methods: geometrically nonlinear behavior. Prep. Admission to the Graduate School of Engineering.

CIV 3545 Advanced Structural Dynamics (2QH)

Winter Quarter, Alternate Years

Matrix formulation of the dynamic equations of equilibrium. Generation of mass, stiffness and damping matrices, static condensation. Modal analysis of linear response. The response spectrum method in modal analysis. Discussion of numerical integration techniques for nonlinear analysis of multi-degree of freedom systems.

CIV 3559 Behavior of Reinforced Concrete Structures (2QH)

Fall Quarter

Moment-Curvature relationships for reinforced concrete cross sections; effect of design parameters in resulting behavior, ductility. Effective stiffness.

CIV 3560 Prestressed Concrete (2QH)
(formerly 01.853) Fall Quarter
Fundamentals of prestressing; design of prestressed concrete beams for flexure and shear; design of end blocks; load balancing method for the analysis of indeterminate prestressed structures; column design. Prep. Undergraduate Reinforced Concrete Design and Structural Analysis.

CIV 3561 Reinforced Concrete Slabs (2QH)
(formerly 01.854) Spring Quarter
Design of two-way slabs by the equivalent frame method; yield line theory; prestressing of slabs; the strip method; and introduction to folded plate design. Prep. Undergraduate Reinforced Concrete Design and Structural Analysis.

CIV 3570 Advanced Steel Design (2QH)
(formerly 01.861) Fall Quarter
An advanced course in elastic design in structural steel. Design problems involving braced and rigid frame structures subject to gravity, wind and seismic loads are considered. Prep. Undergraduate Steel Design and Structural Analysis.

CIV 3571 Inelastic Steel Design (2QH)
(formerly 01.862) Winter Quarter
An advanced course in analysis and design in structural steel with emphasis on plastic behavior including rigid frame buildings and braced multistory frame buildings. Prep. Undergraduate Steel Design and Structural Analysis.

CIV 3575 Bridge Design (2QH)
Spring Quarter, Alternate Years
Behavior of different types of bridge decks, design of typical cases using current AASHTO specifications. Development of mathematical models for computerized analysis of special cases; curved bridge design, skewed decks, etc. Prep. graduate standing (with undergraduate background in steel and concrete design).

CIV 3610 Urban Public Transportation (2QH)
(formerly 01.811) Fall Quarter, Alternate Years
Analysis and planning of public transportation systems, including bus, subway, commuter rail, and paratransit; performance prediction; service evaluation and efficiency control measure; demand prediction; institutional and economic issues. Prep. Admission to Graduate School.

CIV 3630 Traffic Engineering (2QH)
(formerly 01.817) Spring Quarter
Measurement of traffic characteristics and system performance; theory of traffic flow and analytical techniques; systems hardware design and evaluation; current concerns of energy, environmental, and urban amenity impacts; computer applications and institutional characteristics. Prep. Admission to Graduate School.

CIV 3635 Transportation Engineering (2QH)
(formerly 01.820) Winter Quarter, Alternate Years
Description and evaluation of different modes of transportation existing and proposed; their performance and cost characteristics; design, performance, and selection criteria for vehicles and roadbeds. Prep. Admission to Graduate School.

CIV 3640 Theory and Practice of Transportation Planning I (2QH)
(formerly 01.835) Fall Quarter, Alternate Years
Establishments of goals, objectives and criteria; the current planning framework; examination of performance characteristics of transportation systems, including public and private modes on land, water, and airways. Prep. Admission to Graduate School.

CIV 3641 Theory and Practice of Transportation Planning II (2QH)
(formerly 01.836) Fall Quarter, Alternate Years
Continuation of CIV 3640. Transportation demand modeling from regional economic analysis to traffic and public transportation network assignment; technical and economic evaluation; current issues, including environmental assessment, transportation systems management, citizen participation, and planning in developing countries. Prep. CIV 3640 to be taken previously or concurrently.

CIV 3650 Urban Transportation Analysis I (2QH)
(formerly 01.815) Winter Quarter, Alternate Years
Principles of analysis of urban transportation systems including travel demand equilibrium, performance and evaluation techniques using aggregate and disaggregate methods. Prep. CIV 3641 and appropriate graduate statistics courses.

CIV 3651 Urban Transportation Analysis II (2QH)
(formerly 01.816) Spring Quarter, Alternate Years
Continuation of CIV 3650. Conceptualization, formulation, application, and evaluation of mathematical models utilized in urban transportation systems analysis; case studies of representative analyses. The objective of this course is to help prepare students to conceptualize, formulate, apply and evaluate appropriate mathematical modeling techniques in transportation. Prep. CIV 3650.

CIV 3798 Masters Continuation (0QH)
(formerly 01.9X1) Any Quarter

CIV 3799 PhD Continuation (0QH)
(formerly 01.9X4) Any Quarter

CIV 3830 Special Topic in Civil Engineering (2QH)
(formerly 01.992) Fall, Winter, Spring Quarters
Topics of interest to the staff member conducting this course is presented for advanced study. The course is initiated by the appropriate discipline committee and approved by the Department. Prep. Consent of the instructor.

CIV 3835 Special Project in Civil Engineering (2QH)
(formerly 01.995) Any Quarter
An individual effort in an area selected by student and advisor and approved by the Departmental Discipline Committee resulting in a definitive report. Prep. Permission of the Department.

CIV 3850 Master's Report (4QH)
(formerly 01.993) Any Quarter
An individual effort consisting of laboratory and/or literature investigation and analysis or advanced design of a project in an area of civil engineering selected by student and advisor resulting in a definitive report. The report must be completed 7 years from the start of the Master's program. Prep. Permission of the Civil Engineering Department.

CIV 3851 Master's Report (2QH) **Any Quarter**

CIV 3860 Master's Thesis (8QH)
(formerly 01.991) Any Quarter
Analytical and/or experimental research conducted by arrangement with and under the supervision of the department. Prep. Permission of the Civil Engineering Department.

CIV 3861 Master's Thesis (4QH) Any Quarter

CIV 3862 Master's Thesis (2QH) Any Quarter

CIV 3880 PhD Thesis (0QH)
Open to full-time Doctoral students only. Prep. Admission to doctoral program in Civil Engineering.

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

The Department of Electrical and Computer Engineering offers graduate programs leading to the degrees of Master of Science in Electrical Engineering, Master of Science (no specification), Electrical Engineer, and Doctor of Philosophy in Electrical Engineering. The Master of Science degree program may be completed on either a part-time, a continuous full-time, or a cooperative full-time basis. The Electrical Engineer and the PhD degree programs must be completed on a basis consistent with the residence requirements for the degree. The curriculum offers areas of concentration in computer engineering; communications and signal processing; control systems and signal processing; power systems; electronic circuits and semiconductor devices; and fields, waves and optics.

Students in the Industrial Fellowship or Women in Engineering Programs follow the same degree requirements in their subject areas required of all graduate students. Courses offered in the day typically carry four quarter hours of credit; their two-quarter-hour equivalents are given in the evening over two academic quarters.* Each full-time student is responsible for meeting with his or her faculty advisor early in the program so that an appropriate sequence of courses may be arranged. Part-time students should follow the prescribed requirements and confer with their faculty advisor as needed.

Master of Science Degree Requirements

A minimum of forty-four quarter hours of graduate courses with a minimum grade point average of 3.0 is required in all programs. Full-time students are required to complete either an eight quarter hour Master of Science thesis or a four quarter hour seminar as part of their program. Industrial Fellowship students must complete the eight quarter hour Master of Science thesis. Master of Science thesis or seminar are optional for part-time students. For students selecting the thesis option, an Examination Committee shall be formed consisting of the student's major advisor and two full-time faculty members (or one full-time faculty member and one advisor from industry) with background relevant to the thesis topic. The thesis shall be presented by the student to the Committee and to the ECE Department-at-large in the form of a seminar presentation before final approval of the thesis is granted. Please refer to the regulations of the Graduate School of Engineering for detailed information on academic and administrative policies.

Students holding a BSEE degree from an ABET accredited institution will qualify for the Master of Science in Electrical Engineering. An unspecified Master of Science degree will be awarded to those students who do not hold a BSEE.

All graduate courses presuppose mastery of the subject matter of a modern ABET accredited curriculum in electrical engineering. Students with a Bachelor of Science degree in other engineering or related science fields and students with a BSEE degree who have not taken graduate academic work for some time may be required to take one or more of the following undergraduate level prerequisite courses to satisfy any deficiencies. These courses carry no credit toward the graduate degree.

Prerequisite Courses		Credits
ECE 3100	Introduction to Circuits and Systems	4
ECE 3101	Introduction to Electronics	4
ECE 3102	Introduction to Electromagnetic Field Theory	4
ECE 3103	Introduction to Digital Computers	4
ECE 3104	Introduction to Communications	4
ECE 3105	Introduction to System Software I	2
ECE 3106	Introduction to System Software II	2
ECE 3107	Introduction to System Software III	2
ECE 3108	Introduction to Signals and Systems	4
ECE 3120	Power Circuit Analysis I	2
ECE 3130	Electric Machinery Theory I	2

NOTE: The above courses cannot be used toward the 44 quarter hour degree requirement.

* **NOTE:** To earn credit for a part A/part B course you must take both part A and part B (e.g., re: ECE 3222 & ECE 3223).

Computer Engineering

Course Requirements	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	12 QH	12 QH	12 QH
Subject Area Elective Courses	16 QH	20 QH	24 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required	44 QH	44 QH	44 QH

Required Core Courses (2 QH equivalents are in parentheses) Credits

ECE 3211 (3212,3213) Math Methods in Electrical Engineering I.....4
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes.....4

Subject Area Required Courses

ECE 3311 (3312,3313) Software Engineering I.....4
ECE 3391 (3392,3393) Digital Computer Architecture.....4
ECE 3395 (3396,3397) VLSI Design.....4

Subject Area Elective Courses

ECE 3200 Mathematical Methods in Computer Science.....2
ECE 3221 (3222,3223) Linear Systems Analysis.....4
ECE 3231 (3232,3233) Math Methods in Electrical Engineering II.....4
ECE 3314 Software Engineering II.....2
ECE 3321 (3322,3323) Digital Signal Processing.....4
ECE 3325 (3326,3327) Numerical Methods & Computer Applications I....4
ECE 3328 Numerical Methods and Computer Applications II.....2
ECE 3331 (3332,3333) Analog Integrated Circuits.....4
ECE 3341 (3342,3343) Electromagnetic Theory I.....4
ECE 3351 (3352,3353) Digital Communications.....4
ECE 3361 (3362,3363) Detection and Estimation Theory.....4
ECE 3371 (3372,3373) Linear Optimal Control Theory.....4
ECE 3381 (3382,3383) Classical Control Theory.....4
ECE 3394 Microprogramming.....2
ECE 3398 (3399,3400) VLSI Architectures.....4
ECE 3401 Digital System Design with Hardware Desc. Languages.....4
ECE 3440 (3441,3442) Microprocessor - System Design.....4
ECE 3443 (3444,3445) Theory of Computation.....4
ECE 3447 (3448,3449) Switching Theory I.....4
ECE 3450 Switching Theory II.....2
ECE 3451 (3452,3453) Combinatorial Methods & Optimization Tech.....4
ECE 3454 Graph Theory.....2
ECE 3460 Special Topics in Computer Engineering.....2
ECE 3463 (3464,3465) Robot Vision & Sensors.....4
ECE 3466 (3467,3468) Robotics & Automation Systems.....4
ECE 3469 (3470,3471) Fault-Tolerant Computers.....4
ECE 3472 Special Topics in Robotics.....4
ECE 3502 Special Topics in DSP - Fast Algorithms.....2
ECE 3503 Two-Dimensional Digital Signal Processing.....2
ECE 3505 (3506,3507) Digital Image Processing.....4
ECE 3508 (3509,3510) Modern Spectral Analysis.....4
ECE 3511 (3512,3513) Data Communications Networks.....4
ECE 3514 (3515,3516) Error Correcting Codes.....4
ECE 3521 Multidimensional Spectrum Estimation.....2
ECE 3522 Array Signal Processing.....2
ECE 3531 (3532,3533) Adaptive Signal Processing.....4
ECE 3534 (3535,3536) Digital Processing of Speech Signals.....4
ECE 3589 Optical Storage and Display.....2
ECE 3623 (3624,3625) Gate Array Design.....4

ECE 3626 (3627,3628) Integrated Circuits Fabrications Proc. I.....4
ECE 3629 (3630,3631) Integrated Circuits Fabrications Proc. II.....4
ECE 3632 (3633,3637) Design & Analysis of Digital Integ. Circ. II...4
ECE 3646 (3647,3648) Multivariable Control Systems.....4
ECE 3893 Special Problems in Electrical Engineering.....2 or 4
COM 3205 Software Design and Development.....4
COM 3450 Syntactic Pattern Recognition.....4
COM 3640 Parallel Computation.....4
COM 3336 Operating Systems I.....4
or IIS 3607 Operating Systems & Systems Software.....4

Master of Science Thesis ECE 3860.....8
or
Master of Science Seminar ECE 3887,3888.....2 each

Communications and Signal Processing

Course Requirements	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	16 QH	16 QH	16 QH
Subject Area Elective Courses	12 QH	16 QH	20 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required	44 QH	44 QH	44 QH

Required Core Courses (2 QH equivalents are in parentheses) Credits

ECE 3211 (3212,3213) Math Methods in Electrical Engineering I.....4
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes.....4

Subject Area Required Courses

ECE 3221 (3222,3223) Linear Systems Analysis.....4
ECE 3321 (3322,3323) Digital Signal Processing.....4
ECE 3351 (3352,3353) Digital Communications.....4
ECE 3361 (3362,3363) Detection and Estimation Theory.....4

Subject Area Elective Courses

ECE 3231 (3232,3233) Math Methods in Electrical Engineering II.....4
ECE 3325 (3326,3327) Numerical Methods and Computer Applications I..4
ECE 3331 (3332,3333) Analog Integrated Circuits.....4
ECE 3341 (3342,3343) Electromagnetic Theory I.....4
ECE 3344 (3345,3346) Principles of Microwave Engineering.....4
ECE 3371 (3372,3373) Linear Optimal Control Theory.....4
ECE 3381 (3382,3383) Classical Control Theory.....4
ECE 3391 (3392,3393) Digital Computer Architecture.....4
ECE 3395 (3396,3397) VLSI Design.....4
ECE 3398 (3399,3400) VLSI Architectures.....4
ECE 3451 (3452,3453) Combinatorial Methods & Optimization Tech.....4
ECE 3502 Special Topics in DSP: Fast Algorithms.....2
ECE 3503 Two-Dimensional Digital Signal Processing.....2
ECE 3505 (3506,3507) Digital Image Processing.....4
ECE 3508 (3509,3510) Modern Spectral Analysis.....4
ECE 3511 (3512,3513) Data Communications Networks.....4
ECE 3514 (3515,3516) Error Correcting Codes.....4
ECE 3519 (3517,3518) Information Theory.....4
ECE 3520 Special Topics in Communication Theory.....2
ECE 3521 Multidimensional Spectrum Estimation.....2
ECE 3522 Array Signal Processing.....2
ECE 3523 (3524,3525) Communication Systems.....4
ECE 3527,3528,3529 Nonlinear Systems I, II, III.....2 each
ECE 3530 Three Dimensional Picture Processing.....2
ECE 3531 (3532,3533) Adaptive Signal Processing.....4
ECE 3534 (3535,3536) Digital Processing of Speech Signals.....4
ECE 3537 (3538,3539) Multi-User Communications Systems.....4
ECE 3540 (3541,3542) Digital Control System.....4
ECE 3543 (3544,3545) Stochastic Control Theory.....4
ECE 3546 (3547,3548) Adv. Topics in Stochastic & Nonlinear Sys.....4
ECE 3560,3561,3562 Acoustics I, II, III.....2 each
ECE 3563 (3564,3565) Radar Systems I.....4
ECE 3566 Radar Systems II.....2
ECE 3571 (3572,3573) Fourier Optics I.....4
ECE 3574 Fourier Optics II.....2
ECE 3579 Optoelectronics and Fiber Optics.....2
ECE 3582 (3580,3581) Electro-Optics.....4
ECE 3635 (3636,3637) Antennas and Radiation.....4
ECE 3646 (3647,3648) Multivariable Control Systems.....4
ECE 3893 Special Problems in Electrical Engineering.....2 or 4

Master of Science Thesis ECE 3860.....8
or Master of Science Seminar ECE 3887,3888.....2 each

Control Systems and Signal Processing

Course Requirements	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	16 QH	16 QH	16 QH
Subject Area Elective Courses	12 QH	16 QH	20 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required	44 QH	44 QH	44 QH

Required Core Courses (2 QH equivalents are in parentheses)	Credits
ECE 3211 (3212,3213) Math Methods in Electrical Engineering I	4
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes	4
Subject Area Required Courses	
ECE 3221 (3222,3223) Linear Systems Analysis	4
ECE 3321 (3322,3323) Digital Signal Processing	4
ECE 3371 (3372,3373) Linear Optimal Control Theory	4
ECE 3381 (3382,3383) Classical Control Theory	4
Subject Area Elective Courses	
ECE 3231 (3232,3233) Math Methods in Electrical Engineering II	4
ECE 3325 (3326,3327) Numerical Methods and Computer Applications I	4
ECE 3331 (3332,3333) Analog Integrated Circuits	4
ECE 3341 (3342,3343) Electromagnetic Theory I	4
ECE 3351 (3352,3353) Digital Communications	4
ECE 3361 (3362,3363) Detection and Estimation Theory	4
ECE 3391 (3392,3393) Digital Computer Architecture	4
ECE 3395 (3396,3397) VLSI Design	4
ECE 3398 (3399,3400) VLSI Architectures	4
ECE 3440 (3441,3442) Microprocessor-Systems Design	4
ECE 3451 (3452,3453) Combinatorial Methods & Optimization Tech	4
ECE 3463 (3464,3465) Robot Vision & Sensors	4
ECE 3466 (3467,3468) Robotics & Automation System	4
ECE 3472 Special Topics in Robotics	4
ECE 3502 Special Topics in DSP: Fast Algorithms	2
ECE 3503 Two-Dimensional Digital Signal Processing	2
ECE 3505 (3506,3507) Digital Image Processing	4
ECE 3508 (3509,3510) Modern Spectral Analysis	4
ECE 3511 (3512,3513) Data Communication Networks	4
ECE 3514 (3515,3516) Error Correcting Codes	4
ECE 3519 (3517,3518) Information Theory	4
ECE 3520 Special Topics in Communication Theory	2
ECE 3521 Multidimensional Spectrum Estimation	2
ECE 3522 Array Signal Processing	2
ECE 3523 (3524,3525) Communication Systems	4
ECE 3527,3528,3529 Nonlinear Systems I, II, III	2 each
ECE 3530 Three-Dimensional Picture Processing	2
ECE 3531 (3532,3533) Adaptive Signal Processing	4
ECE 3534 (3535,3536) Digital Processing of Speech Signals	4
ECE 3540 (3541,3542) Digital Control Systems	4
ECE 3543 (3544,3545) Stochastic Control Theory	4
ECE 3546 (3547,3548) Adv. Topics in Stochastic & Nonlinear Sys	4
ECE 3560,3561,3562 Acoustics I, II, III	2 each
ECE 3563 (3564,3565) Radar Systems I	4
ECE 3566 Radar Systems II	2
ECE 3574 Fourier Optics II	2
ECE 3646 (3647,3648) Multivariable Control Systems	4
ME 3468 Robot Mechanics and Control	4
ECE 3893 Special Problems in Electrical Engineering	2 or 4
Master of Science Thesis ECE 3860	8
or	
Master of Science Seminar ECE 3887,3888	2 each

Electronic Circuits and Semiconductor Devices

Course Requirements	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	16 QH	16 QH	16 QH
Subject Area Elective Courses	12 QH	16 QH	20 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required	44 QH	44 QH	44 QH

Required Core Courses (2 QH equivalents are in parentheses) Credits

ECE 3211 (3212,3213) Math Methods in Electrical Engineering I.....4
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes.....4

Subject Area Required Courses

ECE 3221 (3222,3223) Linear Systems Analysis.....4
ECE 3331 (3332,3333) Analog Integrated Circuits.....4
ECE 3384 (3385,3386) Char. & Models of Solid State Devices I.....4
ECE 3395 (3396,3397) VLSI Design.....4

Subject Area Elective Courses

ECE 3321 (3322,3323) Digital Signal Processing.....4
ECE 3341 (3342,3343) Electromagnetic Theory I.....4
ECE 3344 (3345,3346) Electromagnetic Theory II.....4
ECE 3388 (3389,3390) Characteristics & Mod. of Solid State Dev. II..4
ECE 3391 (3392,3393) Digital Computer Architecture.....4
ECE 3398 (3399,3400) VLSI Architectures.....4
ECE 3440 (3441,3442) Microprocessor - System Design.....4
ECE 3523 (3524,3525) Communication Systems.....4
ECE 3610 (3611,3612) Electronics of Analog Signal Processing.....4
ECE 3613 (3614,3615) Microwave Semiconductor Devices & Circuits.....4
ECE 3616 (3617,3618) Active Network Synthesis & Design.....4
ECE 3619 (3620,3621) Network Synthesis.....4
ECE 3622 Special Topics in Electronics - Analog MOS LSI.....2
ECE 3623 (3624,3625) Gate Array Design.....4
ECE 3626 (3627,3628) Integrated Circuits Fabrication Proc. I.....4
ECE 3629 (3630,3631) Integrated Circuits Fabrication Proc. II.....4
ECE 3632 (3633,3634) Design & Analysis of Digital Integrated Cir....4
ECE 3638 (3639,3640) Microwave Electron Devices.....4
ECE 3893 Special Problems in Electrical Engineering.....2 or 4

Master of Science Thesis ECE 3860.....8
or
Master of Science Seminar ECE 3887,3888.....2 each

Fields, Waves and Optics

Course Requirements	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses.....	8 QH	8 QH	8 QH
Subject Area Required Courses.....	12 QH	12 QH	12 QH
Subject Area Elective Courses.....	16 QH	20 QH	24 QH
Master of Science Thesis or Seminar....	8 QH	4 QH	0
Minimum Quarter Hours Required.....	44 QH	44 QH	44 QH

Required Core Courses (2 QH equivalents are in parentheses)	Credits
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes	4
ECE 3231 (3232,3233) Math Methods in Electrical Engineering II	4
Subject Area Required Courses	
ECE 3341 (3342,3343) Electromagnetic Theory I	4
ECE 3344 (3345,3346) Electromagnetic Theory II	4
ECE 3347 (3348,3349) Computational Methods in Electromagnetics	4
Subject Area Electives Courses	
ECE 3211 (3212,3213) Math Methods in Electrical Engineering I	4
ECE 3221 (3222,3223) Linear Systems Analysis	4
ECE 3321 (3322,3323) Digital Signal Processing	4
ECE 3384 (3385,3386) Char. & Models of Solid State Devices I	4
ECE 3395 (3396,3397) VLSI Design	4
ECE 3523 (3524,3525) Communication Systems	4
ECE 3560,3561,3562 Acoustics I, II, III	2 each
ECE 3563 (3564,3565) Radar Systems I	4
ECE 3566 Radar Systems II	2
ECE 3571 (3572,3573) Fourier Optics I	4
ECE 3574 Fourier Optics II	2
ECE 3576,3577,3578 Lasers I, II, III	2 each
ECE 3579 Optoelectronics and Fiber Optics	2
ECE 3582 (3580,3581) Electro-Optics	4
ECE 3583,3584,3585 Optical Properties of Matter I, II, III	2 each
ECE 3586 (3587,3588) Principles of Optical Detection	4
ECE 3589 Optical Storage and Display	2
ECE 3590 Optical Instrumentation Design	2
ECE 3591 Spectroscopic Instrumentation	2
ECE 3592 Remote Sensing	2
ECE 3593 Plasma Engineering	4
ECE 3594 (3595,3596) Plasma Theory	4
ECE 3600 (3601,3602) Microwave Properties of Materials	4
ECE 3603 (3604,3605) Propagation in Artificial Structures	4
ECE 3606 (3607,3608) Applications of Plasma Engineering	4
ECE 3613 (3614,3615) Microwave Semiconductor Devices & Circuits	4
ECE 3626 (3627,3628) Integrated Circuits Fabrication Proc. I	4
ECE 3629 (3630,3631) Integrated Circuits Fabrication Proc. II	4
ECE 3635 (3636,3637) Antennas and Radiation	4
ECE 3638 (3639,3640) Microwave Electron Devices	4
ECE 3893 Special Problems in Electrical Engineering	2 or 4
Master of Science Thesis ECE 3860	8
or	
Master of Science Seminar ECE 3887,3888	2 each

Power Systems

Course Requirements	Full-time With Thesis	Full-time With Seminar	Part-time Study
Required Core Courses	8 QH	8 QH	8 QH
Subject Area Required Courses	16 QH	16 QH	16 QH
Subject Area Elective Courses	12 QH	16 QH	20 QH
Master of Science Thesis or Seminar	8 QH	4 QH	0
Minimum Quarter Hours Required	44 QH	44 QH	44 QH

Required Core Courses (2 QH equivalents are in parentheses) Credits

ECE 3211 (3212,3213) Math Methods in Electrical Engineering I.....4
ECE 3241 (3242,3243) Applied Probability & Stochastic Processes.....4

Subject Area Required Courses

ECE 3221 (3222,3223) Linear Systems Analysis.....4
ECE 3302,3303 Power Circuit Analysis II, III.....2 each
ECE 3305 Computers in Power Systems I.....2
ECE 3308 Electric Machinery Theory II.....2
ECE 3341 (3342,3343) Electromagnetic Theory I.....4

Subject Area Elective Courses

ECE 3304 Solid State AC and DC Motor Control Systems.....2
ECE 3306 Computers in Power Systems II.....2
ECE 3309 Electric Machinery Theory III.....2
ECE 3371 (3372,3373) Linear Optimal Control Theory.....4
ECE 3381 (3382,3383) Classical Control Theory.....4
ECE 3412 Power Systems Planning.....2
ECE 3415 Power Systems Protection.....2
ECE 3416 Power Systems Transients.....2
ECE 3423 Special Topics in Power.....2
ECE 3424 Power System Dynamics.....2
ECE 3430,3431 Studies in Electric Power Transmission I, II.....2 each
ECE 3893 Special Problems in Electrical Engineering.....2 or 4
ME 3200 (3201,3202) General Thermodynamics.....4
ME 3343 Power Generation Economics & Planning.....2
ME 3386,3387,3388 Nuclear Engineering I, II, III.....2 each

Master of Science Thesis ECE 3860.....8

or

Master of Science Seminar ECE 3887,3888.....2 each

The Electrical Engineer Degree

The Department of Electrical and Computer Engineering offers the graduate professional degree usually known as the Engineer Degree. This degree usually requires about one year of full-time graduate study beyond the Master of Science degree and may also be pursued on a part-time basis. The official title of the degree is "Electrical Engineer".

Qualification, Degree Candidacy and Examinations

Admission to the Electrical Engineer Degree Program requires that the candidate have a BSEE or MSEE degree with a strong academic background. A student admitted to the Engineer Degree program will be designated as a candidate for this degree. In order to qualify for the degree, a student must maintain a 3.00 grade point average and receive no "F's". In some instances, a student may be required to take special examinations. Such examinations will be determined in each case by the departmental graduate committee.

Course Requirements

The minimum course requirements are 40 quarter hours beyond the Master of Science degree. No more than 10 out of the 40 quarter hours of credit are allowed for thesis and special problems combined. A minimum of 20 quarter hours must be taken in regularly scheduled electrical engineering subjects. All candidates must register for a minimum of 4 quarter hours of course work each quarter as approved by their academic advisor. Registration must be continuous unless withdrawal is approved by the department graduate committee.

Approval for transfer of credit may be given by the departmental graduate committee upon written request from the student. Such requests should be submitted at the time of application to the program. A maximum of 10 quarter hours of credit may be transferred from another school but transfer credits for thesis are not allowed.

After admission to the program, a maximum of 5 years will be allowed for completion of the degree requirements. Extension of this time limit may be granted by the departmental graduate committee.

Language Requirement

No foreign language is required for the Electrical Engineer degree.

Residence Requirement

The residence requirement is satisfied by two academic quarters of full-time graduate work during the same academic year or part-time graduate work during a period of two consecutive academic years subject to approval of the advisor.

Thesis

Each Engineer Degree student must complete a thesis which demonstrates a high level of competence in research, development, or design in the field of electrical engineering. Thesis registration must total at least 6 quarter hours of graduate work. In no case will more that 10 quarter hours be credited towards the degree requirements.

In some cases a Master of Science thesis of superior quality may be used to satisfy the thesis requirement.

A Thesis Examination Committee shall be formed consisting of the student's major advisor and two full-time faculty members (or one full-time faculty member and one advisor from industry) with background relevant to the thesis topic. The thesis shall be presented to the Committee and to the ECE Department-at-large in the form of a seminar presentation before final approval of the thesis is granted.

The Doctor of Philosophy Degree

Qualifying Examination and Degree Candidacy

First, and foremost, the PhD Qualifying Examination is the entrance examination for the admission to the doctoral program. In addition, this examination has the dual purpose of 1): serving as an indicator of the student's capability for successful completion of the program, and 2): serving as a guide to his or her advisor in developing a suitable plan of study tailored to the individual needs of the candidate. A student who has received approval to take the qualifying examination is considered a pre-doctoral student until such time as he or she passes the examination. Upon successful completion of the qualifying examination he or she becomes a PhD candidate.

With these goals in mind, the candidate is urged to take the qualifying examination early in his or her graduate program (i.e., not later than the successful completion of 40 quarter hours of graduate work). The examination is composed of a written and an oral part, and is usually given in the spring quarter of each academic year. For the written part, the student is required to choose three out of the following five areas of concentration:

1. Signals and Systems
2. Fields, Waves and Optics
3. Circuits and Electronics
4. Computer Engineering
5. Energy Conversion and Power Systems

One of the three areas should be that closest to the specialty area in which the student plans to do his or her doctoral thesis work.

The oral part is designed to test general comprehension. Together, the oral and written portions of the examination are designed to test the factual knowledge of a typical undergraduate Electrical Engineering program.

If the examination is failed it may be repeated only with permission of the Graduate Committee upon recommendation of the PhD Qualifying Examination Committee.

Course Requirements

Successful completion of a doctoral program normally requires a minimum of 70 quarter hours of satisfactory graduate level work beyond the Bachelor of Science degree, exclusive of doctoral seminar (required), doctoral reading, and doctoral dissertation.

The course work must include a three-course sequence (12 QH graduate level courses) in each of two minor areas. Both minors must be science, applied science, or a related area. One minor may be chosen from an area of electrical engineering outside the candidate's proposed major area.

Language Requirement

The language requirement may be satisfied in French, German or Russian, with an additional option of English for PhD candidates for whom English is not the native language. Proficiency is tested by way of the Graduate School Foreign Language Exam administered at the University.

Residence Requirement

The residence requirement is satisfied by one year of full-time graduate work or two consecutive years of part-time graduate work. In the latter case, a detailed time schedule must be approved by the student's advisor in order to give evidence that at least half of the time is being devoted to the requirements of the graduate school.

Dissertation

The candidate's dissertation research is directed by a Dissertation Advisor, whom he or she shall select after establishing candidacy. A Dissertation Committee shall be formed consisting of the Advisor and two full-time faculty members with background relevant to the thesis topic. The Committee may also include a person from industry. The Dissertation Committee will approve the dissertation in final form.

Comprehensive Examination

Within three years of his or her establishment of degree candidacy, the student will be required to demonstrate by means of a comprehensive examination a subject matter knowledge satisfactory for the award of the degree.

The comprehensive examination is an oral examination open to the Department of Electrical and Computer Engineering faculty (assistant professor and above in rank) and administered by the student's Dissertation Committee. Departmental faculty will be informed of the examination via a departmental notice at least one week prior to the examination. Normally the examination will be given at the time the Dissertation Proposal is submitted to the Dissertation Committee for approval. As part of this examination the Dissertation Committee will review the student's doctoral program and his or her performance in graduate courses, as well as examine the student on subject matter related to graduate studies and dissertation area.

Final Oral Examination

The final oral examination will include the subject matter of the doctoral dissertation and significant developments in the field of the dissertation work. Other related fields may be included if recommended by the examining committee.

Faculty

John G. Proakis, Chairman

Professors

Devaney, Anthony, PhD, University of Rochester; tomography, electromagnetic wave propagation, inverse scattering
Dolansky, Ladislav, PhD, Harvard University; speech processing and acoustics
Feldman, James, PhD, Carnegie Mellon; physical electronics, computers, energy systems processing, robotics
Grabel, Arvin, ScD, New York University; circuit theory, electronics
Hanania, Jack, PhD, Leeds (England); power systems, electromagnetics
Mulukulta, Sarma, PhD, University of Colorado; power systems, electrical machinery, electromagnetic theory and its applications to electrical machines
Proakis, John, PhD, Harvard University; digital communications, adaptive filtering, estimation, and digital signal processing
Raemer, Harold, PhD, Northwestern University; electromagnetic theory, communications, radar system analysis, microwave theory, electromagnetic scattering, plasma theory
Remillard, Wilfred, PhD, Harvard University; acoustics, numerical analysis, computers
Rochefort, J. Spencer, MS, MIT; communications, electronics, space telemetry
Sandler, Sheldon, PhD, Harvard University; electromagnetics, antennas, pattern recognition, robotics
Schetzen, Martin, ScD, MIT; systems theory, control systems, theory of nonlinear systems
Schwab, Walter, PhD, MIT; electronic circuits, integrated circuits, VLSI
Serafim, Philip, ScD, MIT; electromagnetics, remote sensing
Silevitch, Michael, PhD, Northeastern University; plasma theory, applications of plasma theory to auroral phenomena
Stuart, Robert, PhD, Cambridge University; computer engineering, electronic circuits, VLSI
Vittoria, Carmine, PhD, Yale; electromagnetics, magnetic materials, microwave circuits

Associate Professors

Chan, Chung, PhD, Iowa; plasmas, electromagnetics
Glover, John D., ScD, MIT; power systems, control systems
Hinchey, Sheila Prasad, PhD, Harvard University; electromagnetic theory, antennas, antennas in lossy media, arrays, microstrip
Ingle, Vinaykumar, PhD, Rennselaer Polytechnic Institute; signal processing, image processing
Kellner, Wayne, ScD, MIT; circuit theory, graph theory, computer science
Lob, Walter, MS, MIT; communications theory, communications systems, electronics
Martin, Robert, MS, Northeastern University; circuit theory
McKnight, Stephen, PhD, Maryland; semiconductor devices and materials, electro-optics, electromagnetics
Nikias, Chrysostomos, PhD, SUNY Buffalo; digital signal processing, image processing, spectral estimation
Retter, Charles, PhD, Johns Hopkins; computer systems, coding theory

Assistant Professors

Bechtel, Gordon, PhD, RPI; digital communications, coding
Buus, Soren, PhD, Northeastern University; psychoacoustics, signal processing, microprocessors
Jacobson, Clas, PhD, RPI; control systems
Kai, Francis Yee Tat, PhD, SUNY at Buffalo; physical electronics
Kappos, Efthimios, PhD, UC Berkeley; systems theory, control systems, nonlinear systems
Keller, Catherine, PhD, Illinois; communications, spread spectrum, networks
Li, Nam, PhD, Minnesota; electronics, VLSI design
McGruer, Nicol, PhD, Michigan State; solid state devices, IC fabrication
Merakos, Lazaros, PhD, Connecticut; communications, networks
Moon, Paul, PhD, Virginia; computer engineering, robotics
Navabi, Zainalabedin, PhD, University of Arizona; hardware description languages, VLSI, computer-aided design of digital systems
Raghavan, Ram, PhD, Massachusetts; microwaves, remote sensing, electromagnetics

Rappaport, Carey, ScD, MIT; electromagnetics, microwaves
Richardson, Albert, PhD, Pennsylvania State University; semiconductor devices, VLSI design, microprocessor-based design.
Shafai, Bahram, PhD, George Washington; control systems, digital signal processing
Singh, Amar, PhD, VPISU; electronics, VLSI design
Surya, Charles, PhD, Rochester; solid state devices, electronics
Vai, Man-kuan, PhD, Michigan State; VLSI design, computer engineering
Valavanis, Kimon, PhD, RPI; robotics, control systems

Advisors

An advisor will be assigned to you upon admission to the Graduate School. If you are unable to reach your advisor, you may call the Electrical and Computer Engineering Department office at 437-2164.

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; however, the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine what courses are actually offered in any given quarter and at what day and time.

Note: All courses from ECE 3100 to ECE 3130 are prerequisite courses which cannot be used as part of the minimum 44 quarter hour requirement of the Master of Science.

ECE 3100 Introduction to Circuits and Systems (4QH)
(formerly 03.846) Fall Quarter
The circuit elements (R, L and C) are introduced. Kirchoff's Laws, Tellegan and Thevenin's Theorem. Mesh and nodal analysis. Development of system function approach, Laplace and Fourier transform theory applied to circuit analysis. Sinusoidal steady-state, n-port network theory and power and energy concepts. Prep. Admission to Graduate School

ECE 3101 Introduction to Electronics (4QH)
(formerly 03.847) Winter Quarter
Characteristics of the theoretical physical junction. The Ebers-Moll model for bipolar junction transistors, characteristics of bipolar and field-effect devices, basic digital inverters and logic gates and various logic families. Use of transistors in the design of analog circuits. Biasing, linearized incremental models, load lines, signal flowgraphs, frequency response and gain calculation for single and cascaded stages. Prep. ECE 3100 or equivalent.

ECE 3102 Introduction to Electromagnetic Field Theory (4QH)
(formerly 03.848) Spring Quarter
Definition of scalar and vector fields; vector calculus; concepts of gradient, divergence, curl and the "del" operator; free-space electrostatics; the generalization of the Maxwell equations to the case of time-varying fields; Faraday induction law, wave equations and the place wave solution. Prep. ECE 3100 or equivalent.

ECE 3103 Introduction to Digital Computers (4QH)
(formerly 03.849) Fall Quarter
Basic components of digital systems and methods for their analysis and design, combinational and sequential circuits, integrated circuit logic families and functional building blocks, registers, counters, decoders, multiplexers and memories. Data representation and coding techniques. Central processor alternatives; instruction formats, addressing modes, bus structures, arithmetic units, timing analysis and stacks. Algorithms for arithmetic operations with various data representations. Prep. Admission to Graduate School

ECE 3104 Introduction to Communications (4QH)
(formerly 03.850) Spring Quarter
Review of system theory, convolution, Fourier series, Fourier integral, signal analysis, Fourier methods, correlation functions, density functions, power spectra, amplitude modulation, frequency modulation, phase modulation, sampling theory and digital modulation techniques. Prep. ECE 3108 or equivalent.

ECE 3105 Introduction to System Software I (2QH)
Fall Quarter
A knowledge of Pascal is helpful but not required. Programming style considerations software testing software reliability. Data structures, including stacks, queues, linked lists, trees and graphs. Emphasis on the use of Pascal to implement typical system software routines that use the above data structures. Miscellaneous topics also discussed are modern system software considerations for multiprocessor, array processor and graphic processor systems. Prep. Admission to Graduate School.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3106 Introduction to System Software II (2QH)

Winter Quarter

An analysis of absolute and relocatable program translators. Topics covered are assemblers, disassemblers, macroassemblers, linkers, an overview of compilers, interpreters, simulators and emulators. For a typical lab assignment, the student will design and implement an absolute assembler for a very simplified instruction set. Prep. ECE 3105.

ECE 3107 Introduction to System Software III (2QH)

Spring Quarter

An analysis of operating system structure and concepts. Memory management, fragmentation, paging, virtual memory, job and process scheduling, I/O management, file management. Operating system concepts for multi-user systems. Critical variables, race conditions, Dekkeer's algorithm, some sample multi-user routines. For a typical lab assignment, the student will write simulated paged memory management and process scheduling routines. Prep. ECE 3106

ECE 3108 Introduction to Signals and Systems (4QH)

Winter Quarter

Description and analysis of continuous and discrete time signals and systems. Time domain analysis of linear, time-invariant (LTI) systems. Frequency domain analysis of signals and LTI systems. Laplace and z-transforms. State space descriptions of continuous and discrete time systems. Prep: ECE 3100 or equivalent.

ECE 3120 Power Circuit Analysis I (2QH)

(formerly 03.925) Fall Quarter

Fundamental concepts of single-phase and polyphase power systems; definitions of terms; use of per unit quantities; equivalent circuits of symmetrical 3-phase systems; introduction of symmetrical components; short circuits on systems with a single power source. Prep. BSEE or ECE 3100 and ECE 3102.

ECE 3130 Electrical Machinery Theory I (2QH)

(formerly 03.940) Fall Quarter

Review of magnetic circuit concepts and electromechanical energy-conversion principles; steady-state analysis of transformers, synchronous machines, and induction machines. Prep. BSEE or ECE 3100 and ECE 3102.

ECE 3200 Mathematical Methods in Computer Science (2QH)

(formerly 03.8A1) Fall Quarter

Algebraic concepts relevant to computer science; sets, relations, mapping, orderings, algebraic systems, Boolean algebras, groups, rings, finite fields, introduction to vector spaces and linear algebras over finite fields. Prep. Admission to Graduate School.

ECE 3211 Mathematical Methods in Electrical Engineering I (4QH)

(formerly 03.823) Fall and Winter Quarters

Fundamental Algebraic Concepts; Sets, functions, relations, operations; Algebraic Structures; group, rings, fields, homomorphisms, polynomials; Vector Spaces and Linear Operators; representations, matrices and linear algebraic equations, orthogonality, equivalence and similarity transformations, eigenvalues and eigenvectors, canonical forms, functions of a square matrix, quadratic forms and congruence transformations, orthogonal transformations; Introduction to Polynomial Matrices; Applications to Communications and Control Theory. Prep. Admission to Graduate School

ECE 3212 Mathematical Methods in Electrical Engineering I-A (2QH)

Fall and Winter Quarters

ECE 3212 and ECE 3213 cover the same material with the same prerequisites as ECE 3211, but in two 2QH courses.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3213 Mathematical Methods in Electrical Engineering I-B (2QH)
Winter and Spring Quarters

Continuation of ECE 3212. Prep. ECE 3212.

ECE 3221 Linear Systems Analysis (4QH)
Winter and Spring Quarters

Introduction to the state variable theory of continuous and discrete linear systems. Standard canonical representations. The concept of state and the representation of interconnected systems. Linear spaces. The state equations and their solution. Stability. Introduction to the general control problem in terms of controllability and observability. Prep. ECE 3211, ECE 3108 or equivalent.

ECE 3222 Linear Systems Analysis A (2QH)
Fall and Winter Quarters

ECE 3222 and ECE 3223 cover the same material with the same prerequisites as ECE 3221, but in two 2QH courses.

ECE 3223 Linear Systems Analysis B (2QH)
(formerly 03.826) Winter and Spring Quarters
Continuation of ECE 3222. Prep. ECE 3222.

ECE 3231 Mathematical Methods in Electrical Engineering II (4QH)
Fall Quarter

Complex variable theory; Analytic functions and Cauchy-Riemann equations, complex integration and Cauchy integral formula, Taylor and Laurent Series, the residue theorem, conformal mapping; Laplace transform and its applications, problems in partial differential equations; Generalized Fourier Series and Green's functions; General integral transforms; Sturm-Liouville, Fourier, Hankel, Legendre and other integral transforms. Prep. Admission to Graduate School.

ECE 3232 Mathematical Methods in Electrical Engineering II-A (2QH)
(formerly 03.8C1) Fall Quarter
ECE 3232 and ECE 3233 cover the same material with the same prerequisites as ECE 3231, but in two 2QH courses.

ECE 3233 Mathematical Methods in Electrical Engineering II-B (2QH)
(formerly 03.8C2) Winter Quarter
Continuation of ECE 3232. Prep. ECE 3232

ECE 3241 Applied Probability and Stochastic Processes (4QH)
(formerly 03.902) Fall and Winter Quarters
Introductory probability, sample space and random variables, examples of discrete and continuous probability distribution functions, averages, moments and characteristic function, multivariate distributions, change of variables and functions of variables, central limit theorem, description of stochastic vectors. General concepts of stochastic processes, stationarity and ergodicity, stochastic continuity and differentiation, the Gaussian process, linear systems with stochastic inputs, correlation functions and power spectra, matched filtering, stochastic orthogonality and linear mean-square estimation filtering and prediction. Prep. ECE 3108 or equivalent.

ECE 3242 Applied Probability and Stochastic Processes A (2QH)
(formerly 03.900) Fall and Winter Quarters
ECE 3242 and ECE 3243 cover the same material with the same prerequisites as ECE 3241, but in two 2QH courses.

ECE 3243 Applied Probability and Stochastic Processes B (2QH)
(formerly 03.901) Winter and Spring Quarters
Continuation of ECE 3242. Prep. ECE 3242.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3302 Power Circuit Analysis II (2QH)
(formerly 03.926) Winter Quarter
A continuation of ECE 3120 Power Circuit Analysis I. Sequence impedances of various power-system elements are considered from an application point of view; unsymmetrical faults on otherwise symmetrical 3-phase systems; open conductors and asymmetrical connections and loadings; analysis of simultaneous faults on 3-phase systems. Prep. ECE 3120.

ECE 3303 Power Circuit Analysis III (2QH)
(formerly 03.927) Spring Quarter
A continuation of ECE 3302, Power Circuit Analysis II. Introduction of Clarke components and applications in analysis of asymmetrical systems and faults; application of Clarke components to the solution of surge phenomena problems; transmission line theory; fundamentals of systems stability. Prep. ECE 3302.

ECE 3304 Solid State AC and DC Motor Control Systems (2QH)
(formerly 03.929) Fall Quarter
The application of solid-state devices to the control of AC and DC electrical machinery, including rectifiers, inverters, choppers and cyclo-converters, as applied to drive systems in industry and transportation. Emphasis on a case method approach. Prep. BSEE or ECE 3100 and ECE 3101, or equivalent.

ECE 3305 Computers in Power Systems I (2QH)
(formerly 03.935) Fall Quarter
Techniques used in solving power system problems with the digital computer. Matrix formulations are examined, followed by a detailed treatment of the short-circuit problem, including balanced and unbalanced faults. Various iterative techniques are studied for the solution of the power-flow problem. Prep. ECE 3120.

ECE 3306 Computers in Power Systems II (2QH)
(formerly 03.936) Winter Quarter
Practical considerations of solving large scale networks. Network reductions, distribution factors and contingency analysis techniques. Digital models for regulated generators, fixed and load tap changing transformers and HVDC transmission lines. Computer methods for economic dispatch, loss coefficients and application of pumped hydro are developed. Prep. ECE 3305.

ECE 3308 Electrical Machinery Theory II (2QH)
(formerly 03.941) Winter Quarter
Mathematical description of a synchronous machine; per-unit representation; steady-state theory and transient performance; flux distribution and saturation in synchronous machines. Prep. ECE 3130.

ECE 3309 Electrical Machinery Theory III (2QH)
(formerly 03.942) Spring Quarter
Review of transient behavior of synchronous machines; stability studies and excitation systems; synchronous machine modeling; generator protection; trends in development of large generators. Prep. ECE 3308.

ECE 3311 Software Engineering I (4QH)
(formerly 03.896) Fall Quarter
An introduction to basic concepts in software engineering principles is given. Techniques of structured software design and testing are discussed along with issues of program reliability and complexibility. Management techniques are touched upon and a case study of a typical large software problem is undertaken. Prep. ECE 3105, 3106, 3107 or equivalent, and a knowledge of a high level programming language.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3312 Software Engineering I-A (2QH)
(formerly 03.893) Fall and Winter Quarters
ECE 3312 and ECE 3313 cover the same material with the same prerequisites as ECE 3311, but in two 2QH courses.

ECE 3313 Software Engineering I-B (2QH)
(formerly 03.894) Winter and Spring Quarters
Continuation of ECE 3312. Prep. ECE 3312.

ECE 3314 Software Engineering II (2QH)
(formerly 03.895) Spring Quarter
Focus turns away from the general issues of the first two courses in this sequence and towards a very specific issue, modular design of software. Issues of stepwise-refinement and top-down design are explored in depth and organizational/data-flow issues are considered. Prep. ECE 3311 or 3313.

ECE 3321 Digital Signal Processing (4QH)
(formerly 03.8T9) Winter and Spring Quarters
Theory and practice of modern signal processing techniques. Characteristics of discrete signals and systems; sampling and A/D conversion; difference equations; convolution; the z-transform, the Fourier transform and the discrete Fourier transform; fast Fourier transform algorithms; chirp z-transform algorithm; digital filter realizations; design techniques for IIR and FIR digital filters; computer programs for filter design; quantization effects in digital signal processing. Prep. ECE 3221.

ECE 3322 Digital Signal Processing A (2QH)
(formerly 03.8T7) Fall and Winter Quarters
ECE 3322 and ECE 3323 cover the same material with the same prerequisites as ECE 3321, but in two 2QH courses.

ECE 3323 Digital Signal Processing B (2QH)
(formerly 03.8T8) Winter and Spring Quarters
Continuation of ECE 3322. Prep. ECE 3322.

ECE 3325 Numerical Methods and Computer Applications I (4QH)
(formerly 03.8T0) Winter Quarter
Survey of numerical methods applied to engineering and scientific problems with emphasis on machine implementation and problem solving; roundoff and cumulative errors; roots of polynomials and nonlinear functions; systems of linear and nonlinear algebraic equations; orthogonal function, least square Chebyshev approximation of functions; interpolation; numeric quadrature; ordinary and partial differential equations. Prep. Admission to Graduate School and a working knowledge of FORTRAN.

ECE 3326 Numerical Methods and Computer Applications I-A (2QH)
(formerly 03.8T1) Fall and Winter Quarters
ECE 3326 and ECE 3327 cover the same material with the same prerequisites as ECE 3325, but in two 2QH courses.

ECE 3327 Numerical Methods and Computer Applications I-B (2QH)
(formerly 03.8T2) Winter and Spring Quarters
Continuation of ECE 3326. Prep. ECE 3326.

ECE 3328 Numerical Methods and Computer Applications II (2QH)
(formerly 03.8T3) Spring Quarter
Spectral analysis, including fast Fourier transforms, Hilbert transforms, convolution, and correlation techniques. Optimization, including dynamic programming and steepest descent techniques. PERT and linear programming. Other selected topics. Prep. ECE 3325 or ECE 3327.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3331 Analog Integrated Circuits (4QH)
(formerly 03.842) Fall Quarter
Active transistor circuits and systems are treated with emphasis on modern integrated circuit architectures. Bipolar and field-effect (NMOS and CMOS) implementations of analog circuits are presented. Characteristics and behaviors of analog I.C. structures are explored through the study of circuits such as, operational amplifiers, instrumentation amplifiers, voltage comparators, various types of filter configuration and integrators as well as multipliers and logarithmic amplifiers. Features covered include linearity, dynamic range, slew-rate limiting and speed and gain bandwidth trade-offs. The role of feedback in stabilizing, linearizing and otherwise enhancing the performance of analog circuits is treated in detail. Noise limitations on circuit performance are explored. Noise models of devices and circuits are developed, leading to the prediction of system noise performance and techniques for optimizing signal-to-noise ratios. Prep. ECE 3101 or equivalent.

ECE 3332 Analog Integrated Circuits A (2QH)
(formerly 03.840) Fall Quarter
ECE 3332 and ECE 3333 cover the same material with the same prerequisites as ECE 3331, but in two 2QH courses.

ECE 3333 Analog Integrated Circuits B (2QH)
(formerly 03.841) Winter Quarter
Continuation of ECE 3332. Prep. ECE 3332

ECE 3341 Electromagnetic Theory I (4QH)
(formerly 03.877) Fall Quarter
Emphasis is on the fundamental equations, their physical meaning, principal mathematical techniques and important engineering applications. Sources of the EM field. Lorentz force equation. Definition of the relations and point relations (differential equations and boundary conditions). Electrogmagnetic energy and power. Propagation of plane waves in homogeneous media. Reflection and transmission. Scalar and vector potentials. Solutions in the absence of boundaries for static and dynamic problems, with or without symmetry. Solutions to boundary value problems. Green's functions. Transmission lines, resonators. Dielectric slab guide. Prep. ECE 3102 or equiv.

ECE 3342 Electromagnetic Theory I-A (2QH)
(formerly 03.875) Fall Quarter
ECE 3342 and ECE 3343 cover the same material with the same prerequisites as ECE 3341, but in two 2QH courses.

ECE 3343 Electromagnetic Theory I-B (2QH)
(formerly 03.876) Winter Quarter
Continuation of ECE 3342. Prep. ECE 3342.

ECE 3344 Electromagnetic Theory II (4QH)
(formerly 03.87G) Winter Quarter
Examination of important electrodynamic applications by the use of advanced mathematical techniques. General theory of waveguides and resonators with application to the cylindrical geometry. Dielectric rod waveguide. Optical fibers. Radiation. Linear antennas. Loop antenna. Linear arrays. Ray optics. Scattering and diffraction of waves for planar, cylindrical and spherical geometries. Effects of random media. Prep. ECE 3341.

ECE 3345 Electromagnetic Theory II-A (2QH)
(formerly 03.878) Winter Quarter
ECE 3345 and ECE 3346 cover the same material with the same prerequisites as ECE 3344, but in two 2QH courses.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3346 Electromagnetic Theory II-B (2QH)

(formerly 03.879) Spring Quarter
Continuation of ECE 3345. Prep. ECE 3345.

ECE 3347 Computational Methods in Electromagnetics (4QH)
(formerly 03.8H7) Winter Quarter
Solutions to problems in electromagnetics are presented using a wide variety of numerical and computational methods. Finite element methods are used to solve problems in electrostatics, diffusion, and wave propagation. Moment methods are used to solve the integral equations related to currents and charges on wire structures. Direct and inverse scattering is treated by approximate methods related to physical and geometrical optics. Computational methods are introduced in relation to the asymptotic evaluation of radiation integrals and in basically non-numerical approaches to solving the integral equations that occur in electromagnetics. Electromagnetic data handling, sampling, and processing is also treated. Prep. ECE 3341, 3344.

ECE 3348 Computational Methods in Electromagnetics A (2QH)
(formerly 03.8H5) Fall Quarter
ECE 3348 and ECE 3349 cover the same material with the same prerequisites as ECE 3347, but in two 2QH courses.

ECE 3349 Computational Methods in Electromagnetics B (2QH)
(formerly 03.8H6) Winter Quarter
Continuation of ECE 3348. Prep. ECE 3348.

ECE 3351 Digital Communications (4QH)
(formerly 03.9C3) Winter Quarter
The theoretical and practical aspects of digital communications in the presence of channel distortion and additive noise. Topics covered include the basic binary and M-ary modulation techniques, namely, PSK, PAM, FSK, orthogonal and biorthogonal signals, and their performance in an additive Gaussian noise channel; signal waveforms constructed from binary block and convolutional codes; hard-decision decoding and soft-decision decoding of coded signal waveforms; performance of coded waveforms in an additive white Gaussian noise channel. Signal design techniques for band-limited channels; Nyquist criteria; effect of channel amplitude and delay distortion on digital signals; discussion of several adaptive equalization algorithms for combatting intersymbol interference; maximum likelihood sequence estimation and the Viterbi algorithm; the characterization of fading multipath channels; diversity reception techniques; coding for fading channels. Prep. ECE 3241 and ECE 3104 or equivalent.

ECE 3352 Digital Communications A (2QH)
(formerly 03.9C1) Fall Quarter
ECE 3352 and ECE 3353 cover the same material with the same prerequisites as ECE 3351, but in two 2QH courses.

ECE 3353 Digital Communications B (2QH)
(formerly 03.9C2) Winter Quarter
Continuation of ECE 3352. Prep. ECE 3352.

ECE 3361 Detection and Estimation Theory (4QH)
(formerly 03.909) Winter Quarter
The classical theory of detection and estimation of signals in noise with emphasis on implementation of the theory. Particular topics include: hypothesis testing criteria; coherent detection of M-ary signals; diversity receiver; calculation of error probabilities. Detection in colored noise; parameter estimation using Bayes, maximum-likelihood, a maximum land posteriori criteria; applications of the theory to digital communications and radar. Prep. ECE 3241.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3362 Detection and Estimation Theory A (2QH)
(formerly 03.906) Winter Quarter
ECE 3362 and ECE 3363 cover the same material with the same prerequisites as ECE 3361, but in two 2QH courses.

ECE 3363 Detection and Estimation Theory B (2QH)
(formerly 03.907) Spring Quarter
Continuation of ECE 3362. Prep. ECE 3362.

ECE 3371 Linear Optimal Control Theory (4QH)
(formerly 03.9A8) Spring Quarter
Analysis and design of linear multivariable feedback control systems. State Space techniques are emphasized. The problems addressed include: linear optimal regulators and observers, optimal output feedback, tracking and disturbance rejection, robustness analysis and loop shaping. Prep: ECE 3221, ECE 3241.

ECE 3372 Linear Optimal Control Theory A (2QH)
(formerly 03.9A6) Winter Quarter
ECE 3372 and ECE 3373 cover the same material with the same prerequisites as ECE 3371, but in two 2QH courses.

ECE 3373 Linear Optimal Control Theory B (2QH)
(formerly 03.9A7) Spring Quarter
Continuation of ECE 3372. Prep. ECE 3372.

ECE 3381 Classical Control Theory (4QH)
(formerly 03.959) Fall Quarter
Basic systems modeling; steady state and transient response analysis. Introduction to root-locus plots, Bode plots, Nyquist plots, and Nichols chart. The design of first order cascade and feedback compensators using the above plots. Pole-zero synthesis techniques and design techniques for the optimal linear regulator problem. Prep: ECE 3108 or equivalent.

ECE 3382 Classical Control Theory A (2QH)
(formerly 03.957) Fall Quarter
ECE 3382 and ECE 3383 cover the same material with the same prerequisites as ECE 3381, but in two 2QH courses.

ECE 3383 Classical Control Theory B (2QH)
(formerly 03.958) Winter Quarter
Continuation of ECE 3382. Prep. ECE 3382.

ECE 3384 Characteristics and Models of Solid State Devices I (4QH)
(formerly 03.8G0) Winter Quarter
Designed to develop insight into the physics of semiconductors and the operation of semiconductor devices. Topics include: crystal structure, energy bands, carrier concentration at thermal equilibrium, semiconductor statistics, carrier transport phenomena, p-n junction theory, charge storage and diode transients, bipolar junction transistors, charge-control model, Gummel-Poon model. Prep: ECE 3101 or equivalent.

ECE 3385 Characteristics and Models of Solid State Devices I-A (2QH)
(formerly 03.8G1) Fall Quarter
ECE 3385 and ECE 3386 cover the same material with the same prerequisites as ECE 3384, but in two 2QH courses. Prep: ECE 3101 or equivalent.

ECE 3386 Characteristics and Models of Solid State Devices I-B (2QH)
(formerly 03.8G2) Winter Quarter
Continuation of ECE 3385. Prep. ECE 3385.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3388 Characteristics and Models of Solid State Devices II (4QH)
Spring Quarter
Metal-semiconductor contacts, methods of measurement of barrier height, MIS diode, C-V measurement to evaluate the interface-trapped charges; MOSFET device and structure, device scaling and second-order effects, CMOS structure; solid state microwave devices such as MESFET, MODFET, and the heterojunction bipolar transistor (HBT) will be discussed. An examination of noise in the microwave devices will be included. Prep. ECE 3384.

ECE 3389 Characteristics and Models of Solid State Devices II-A (2QH)
Winter Quarter
ECE 3389 and 3390 cover the same material with the same prerequisites as ECE 3388, but in two 2 QH courses. Prep. ECE 3384.

ECE 3390 Characteristics and Models of Solid State Devices II-B (2QH)
Spring Quarter
Continuation of ECE 3389, Prep. ECE 3389.

ECE 3391 Computer Architecture (4QH)
(formerly 03.979) Winter Quarter
This course deals with the design of new architectures as well as understanding those already extant. Both the hardware and system software which permit the system to deal with multiple processes sharing common resources such as a processor, a bus, primary memory and disk storage are considered. Topics include the operating system, caches and memory management, and I/O processing. The software topics include some exercises in a small subset of VAX assembly language, typical HLL constructs and their translation to VAX assembly code, instruction and addressing mode frequencies, and consideration of the value of different data types. RISC and CISC architectures are introduced and issues concerning the subdivision of computational tasks and hard-wiring vs. microprogramming are discussed. Details of a specific design are introduced to focus on solving such critical operations as pipeline design and efficient interrupt handling. Prep. A good working knowledge of high-level-language programming (Pascal or C, for example), a course in logic (gates, minimization, sequential and combinatorial circuits), and at least a rudimentary idea of assembly language programming and how a computer functions internally.

ECE 3392 Digital Computer Architecture A (2QH)
(formerly 03.972) Fall and Winter Quarters
ECE 3392 and ECE 3393 cover the same material with the same prerequisites as ECE 3391, but in two 2QH courses.

ECE 3393 Digital Computer Architecture B (2QH)
(formerly 03.973) Winter and Spring Quarters
Continuation of ECE 3392. Prep. ECE 3392.

ECE 3394 Microprogramming (2QH)
(formerly 03.974) Spring Quarter
Topics in microprogramming and emulation including microprogramming concepts and techniques; microprogramming design approach using register transfer notation and precedence graphs; microprogrammed computers, bit-slice microprogramming, microprogramming a specific machine for emulation using a microprogramming language and its simulator; current trends in microprogramming languages and support tools. Prep. ECE 3391 or 3393.

ECE 3395 VLSI Design (4QH)
(formerly 03.8E6) Fall Quarter
MOS devices and circuits, electrical and logic design, logic arrays; fabrication, design rules, electrical parameters, delays; NMOS and CMOS subsystem design, examples; laboratory design project including layout design and verification. Prep. ECE 3101 and ECE 3103 or equivalent.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3396 VLSI Design A (2QH)
(formerly 03.8E4) Fall Quarter
ECE 3396 and ECE 3397 cover the same material with the same prerequisites as ECE 3395, but in two 2QH courses.

ECE 3397 VLSI Design B (2QH)
(formerly 03.8E5) Winter Quarter
Continuation of ECE 3396. Prep. ECE 3396.

ECE 3398 VLSI Architectures (4QH)
Winter Quarter
System clocking and system design issues; control processing data path design; systolic arrays; bit serial architectures; design for testability; introduction to silicon compilation; laboratory project. Prep. ECE 3395.

ECE 3399 VLSI Architectures A (2QH)
Winter Quarter
ECE 3399 and 3400 cover the same material with the same prerequisites as ECE 3398, but in two 2 QH courses. Prep. ECE 3395.

ECE 3400 VLSI Architectures B (2QH)
Spring Quarter
Continuation of ECE 3399. Prep. ECE 3399.

ECE 3401 Digital Systems Design with Hardware Description Languages (4QH)
Spring Quarter
This course covers design, simulation, modeling, and implementation of complex digital systems using high level computer hardware description languages (HDL). It begins with a description of digital system design hierarch, and abstraction. Next a brief overview of available design tools and simulation programs will be given. HDLs, with emphasis on VHDL and AHPL will then be introduced. Using these languages for design and verification of digital systems at different levels of abstraction will be studied. Students will use VHDL software for design and simulation of large digital circuits. Silicon compilation, computer-aided design and automatic generation of hardware will also be addressed. Prep. ECE 3391.

ECE 3412 Power System Planning (4QH)
(formerly 03.931) Spring Quarter
Engineering and economic considerations underlying the planning and development of modern interconnected power systems. Consideration of overall planning strategies involved in economic comparison of alternative development schemes. Prep. ECE 3120.

ECE 3415 Power Systems Protection (2QH)
(formerly 03.932) Winter Quarter
Consideration of protection applied to generation, transmission, and distribution. Investigation of the characteristics and operating principles of various methods of protective relaying; analysis of current techniques pertaining to system protection. Prep. ECE 3303.

ECE 3416 Power System Transients (2QH)
(formerly 03.933) Fall Quarter
Transients in power systems due to system switching, lightning, or faults. Traveling-wave phenomena; insulation coordination; overvoltages due to disturbances on the system; surge protection. Prep. ECE 3303.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3423 Special Topics in Power (2QH)
(formerly 03.944) Spring Quarter
Directed reading and discussion of topics of special interest in the power field. Series of lectures by guest speakers from industry on topics of particular interest to the power student. Prep. Permission of Instructor.

ECE 3424 Power System Dynamics (2QH)
(formerly 03.945) Spring Quarter
Transient system models; small and large scale oscillations; solution of swing equation for single and multi-generator cases; load frequency and voltage controllers and transient stability. Prep. ECE 3303.

ECE 3430 Studies in Electric Power Transmission I (2QH)
(formerly 03.955) Fall Quarter
Elements in the design of AC overhead transmission lines; thermal limitation, series and shunt compensation, environmental effects; consideration of transposition, induced effects, and insulation level. Underground alternatives to overhead lines. Elements of distribution. Prep. ECE 3303.

ECE 3431 Studies in Electric Power Transmission II (2QH)
(formerly 03.956) Winter Quarter
Fundamental concepts of high voltage DC power transmission; rectifier and inverter performance; regulation; protection; reactive power and filter requirements; practical arrangement of DC lines; the impact of a DC line on overall power system operation. Prep. ECE 3303.

ECE 3440 Microprocessor-System Design (4QH)
(formerly 03.8F3) Spring Quarter
Design and programming of a microcomputer system, including bus interface and timing, interrupts, various peripheral chips, and debugging with the HP64000 emulator. Prep. ECE 3103, or equivalent.

ECE 3441 Microprocessor-System Design A (2QH)
(formerly 03.8F1) Fall Quarter
ECE 3441 and ECE 3442 cover the same material with the same prerequisites as ECE 3440, but in two 2QH courses.

ECE 3442 Microprocessor-System Design B (2QH)
(formerly 03.8F2) Winter Quarter
Continuation of ECE 3441. Prep. ECE 3441.

ECE 3443 Theory of Computation (4QH)
(formerly 03.8F0) Spring Quarter
This course deals with basic abstract models of computation. Topics include Turing machines, primitive recursive functions, recursive systems of equations and abstract families of algorithms. Unsolvable problems are examined, along with the Recursion Theorem. Prep. ECE 3200.

ECE 3444 Theory of Computation A (2QH)
(formerly 03.985) Fall Quarter
ECE 3444 and ECE 3445 cover the same material with the same prerequisites as ECE 3443, but in two 2QH courses.

ECE 3445 Theory of Computation B (2QH)
(formerly 03.986) Winter Quarter
Continuation of ECE 3444. Prep. ECE 3444.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3447 Switching Theory I (4QH)
(formerly 03.966) Spring Quarter
Logical design of combinational switching circuits, including minimization and decomposition of switching functions; multiple output networks; symmetric networks; threshold logic, fault detection. Logic design of sequential switching circuits including finite-state machine model; iterative networks; capabilities and limitations of finite-state machines; state equivalence; synthesis of asynchronous sequential circuits; state assignment problem and partition theory; machine decomposition. Logical design of sequential switching circuits, including the finite-state machine model; iterative networks; capabilities and limitations of finite-state machines; state equivalence; synthesis of asynchronous sequential circuits; state assignment problem and partition theory; machine decomposition. Prep. ECE 3200.

ECE 3448 Switching Theory I-A (2QH)
(formerly 03.967) Fall Quarter
ECE 3448 and ECE 3449 cover the same material with the same prerequisites as ECE 3447, but in two 2QH courses.

ECE 3449 Switching Theory I-B (2QH)
(formerly 03.968) Winter Quarter
Continuation of ECE 3448. Prep. ECE 3448.

ECE 3450 Switching Theory II (2QH)
(formerly 03.969) Spring Quarter
Selected topics from the theory of finite automata, including such topics as machine experiments; information lossless machines; linear sequential machines; finite-state recognizers. Prep. ECE 3447 or 3449.

ECE 3451 Combinatorial Methods and Optimization Techniques (4QH)
(formerly 03.888) Spring Quarter
An introductory course in applied combinatorial mathematics which treats selected topics in enumerative analysis. Particular subjects include permutations, combinations, generating functions, recurrence relations, and the principle of inclusion and exclusion. Polya's theory of counting; selected topics in optimization techniques, which include transport networks, matching theory, linear programming, and an introduction to dynamic programming. Prep. ECE 3200

ECE 3452 Combinatorial Methods and Optimization Techniques A (2QH)
(formerly 03.898) Winter Quarter
ECE 3452 and ECE 3453 cover the same material with the same prerequisites as ECE 3451, but in two 2QH courses.

ECE 3453 Combinatorial Methods and Optimization Techniques B (2QH)
(formerly 03.899) Spring Quarter
Continuation of ECE 3452. Prep. ECE 3452.

ECE 3454 Graph Theory (2QH)
(formerly 03.837) Spring Quarter
Fundamentals of graph theory, including blocks, trees, connectivity, partitions, traversability, line graphs, factorization, coverings, planarity, matrices, digraphs, and enumeration problems. Selected applications of graph theory in such fields as network theory, switching theory, and computer science. Prep. ECE 3211.

ECE 3460 Special Topics in Computer Engineering (2QH)
(formerly 03.988) Spring Quarter
Aspects of computer engineering not covered in other courses. The subject matter may change from year to year.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3463 Robot Vision and Sensors (4QH)

Winter Quarter

Methods of acquisition, representation and processing of real world information for robot control. Major areas of interest: Robot vision and robot sensors. Robot vision covers low-level vision, real time image understanding, theory of motion. Introduction to high-level vision by examination of problems associated with part acquisition, representation and reorientation. Robot sensors covers both internal and external sensors. Internal sensors monitor the state of robot systems. External sensors allow the system to interact with its environment. Force/torque, touch, proximity and tactile sensors are examined. Prep. ECE 3466.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3464 Robot Vision and Sensors A (2QH)

Winter Quarter

ECE 3464 and ECE 3465 cover the same material with the same prerequisites as ECE 3463, but in two 2QH courses.

ECE 3465 Robot Vision and Sensors B (2QH)

Spring Quarter

Continuation of ECE 3464. Prep. ECE 3464.

ECE 3466 Robotics and Automation Systems (4QH)
(formerly 03.874)

Fall Quarter

Methods of design and operation of general purpose and industrial manipulator systems. Robot mobility criteria. Kinematic and dynamic models of mechanical arms. Joint solutions and motion characteristics. Trajectory planning. Arm control through coordinate transformations, classical feedback methods and modern closed-loop control techniques. Real-time control of robotic systems. Prep. ECE 3221.

ECE 3467 Robotics and Automation Systems A (2QH)

Fall Quarter

ECE 3467 and ECE 3468 cover the same material with the same prerequisites as ECE 3466, but in two 2QH courses.

ECE 3468 Robotics and Automation Systems B (2QH)

Winter Quarter

Continuation of ECE 3467. Prep. ECE 3467.

ECE 3469 Fault-Tolerant Computers (4QH)

Winter Quarter

Concepts of computer systems structures and specifications; software and hardware interactions; failure and reliability; errors and faults. Study of different types of faults; fault prevention and fault tolerance; redundancy management; reliability and availability. Comparisons of existing fault-tolerant computer architectures such as SIFT, FTMP, Tandem 16, and Stratus/32. Techniques of error detection and error recovery. Mechanisms for damage confinement and damage assessment. Study of software fault tolerance techniques such as recovery block scheme, deadline mechanism, and N-version programming scheme. Prep. ECE 3391.

ECE 3470 Fault-Tolerant Computers A (2QH)

Winter Quarter

ECE 3470 and ECE 3471 cover the same material with the same prerequisites as ECE 3469, but in two 2QH courses.

ECE 3471 Fault-Tolerant Computers B (2QH)

Spring Quarter

Continuation of ECE 3470. Prep. ECE 3470.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3472 Special Topics in Robotics (4QH)

Spring Quarter

Dynamic analysis of manipulator motion, closed-form dynamic robot model construction and real-time model optimization. Analysis of the influence of actuator models complexity on manipulator control. Adaptive and non-adaptive control of manipulator robots with variable parameters. Controllability and stability analysis. State-space constraints and avoidance of obstacles. Adaptive identification of states, parameters and variable payload. Prep. ECE 3466.

ECE 3502 Special Topics in Digital Signal Processing - Fast Algorithms (2QH)
(formerly 03.8U4) Fall Quarter

Fast algorithms for implementation of digital filters and discrete Fourier transforms: FFT, convolution algorithm, Number Theoretic Transforms (NTT), filtering computation, and polynomial transforms. Prep. ECE 3321.

ECE 3503 Two-Dimensional Digital Signal Processing (2QH)
(formerly 03.8U7) Winter Quarter

Two-dimensional digital signal processing which is finding wide applications in many diversified areas. Covers 2-D shift invariant systems along with their stability, the 2-D Discrete Fourier Transform (DFT) and its FFT implementation, and
2-D digital filter design and implementation. Prep. ECE 3321.

ECE 3505 Digital Image Processing (4QH)
(formerly 03.9D3) Spring Quarter

Topics include: generation of digital image from the source, image digitizers and display devices, image transforms, enhancement techniques such as histogram, equalization, edge sharpening etc.; restoration by Wiener and Kalman filters, image coding using run length coding, DPCM, transform coding and feature analysis. Prep. ECE 3321.

ECE 3506 Digital Image Processing A (2QH)
(formerly 03.9D1) Fall Quarter

ECE 3506 and ECE 3507 cover the same material with the same prerequisites as ECE 3505, but in two 2QH courses.

ECE 3507 Digital Image Processing B (2QH)
(formerly 03.9D2) Winter Quarter

Continuation of ECE 3506. Prep. ECE 3506.

ECE 3508 Modern Spectral Analysis (4QH)

Fall Quarter

Introduction; conventional methods of spectrum estimation: periodogram and autocorrelation methods with their smooth versions; the maximum entropy method with and without uncertainty in the correlation measurements; the Levinson algorithm; the minimum energy method, weighted Burg techniques, forward-backward least-squares, covariance least-squares; moving average (MA) and ARMA spectrum estimation; model order selection criteria; harmonic decomposition methods: Prony, Pisarenko and singular value decomposition methods; introduction to multichannel conventional spectrum estimation techniques; parametric modeling of multichannel time series; the Levinson-Wiggins-Robbins algorithm; multichannel AR spectrum estimation techniques. Prep. ECE 3321.

ECE 3509 Modern Spectral Analysis A (2QH)

Fall Quarter

ECE 3509 and 3510 cover the same material with the same prerequisites as ECE 3508, but in two 2 QH courses. Prep. ECE 3321.

ECE 3510 Modern Spectral Analysis B (2QH)

Winter Quarter

Continuation of ECE 3509. Prep. ECE 3509.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3511 Data Communications Networks (4QH)
(formerly 03.8F6) Spring Quarter
Elements of computer-communication networks; network topology and design; elements of protocols, routing and network control; queuing and congestion control; description and comparison of several existing computer networks. Prep. ECE 3241.

ECE 3512 Data Communications Networks A (2QH)
(formerly 03.8F4) Winter Quarter
ECE 3512 and ECE 3513 cover the same material with the same prerequisites as ECE 3511, but in two 2QH courses.

ECE 3513 Data Communications Networks B (2QH)
(formerly 03.8F5) Spring Quarter
Continuation of ECE 3512. Prep. ECE 3512.

ECE 3514 Error Correcting Codes (4QH)
(formerly 03.9A0) Spring Quarter
Error correcting codes and their decoding techniques which show promise for applications in digital communication, control and computer systems. Emphasis is placed on the linear block codes based on algebraic structures; cyclic codes for random error correction (B-C-H codes) and burst error correction. Convolutional codes and decoding including the Viterbi algorithm, arithmetic codes. Combination of codes. Coding for ranging and synchronization. Prep. ECE 3211.

ECE 3515 Error Correcting Codes A (2QH)
(formerly 03.9A1) Winter Quarter
ECE 3515 and ECE 3516 cover the same material with the same prerequisites as ECE 3514, but in two 2QH courses.

ECE 3516 Error Correcting Codes B (2QH)
Spring Quarter
Continuation of ECE 3515. Prep. ECE 3515.

ECE 3517 Information Theory A (2QH)
(formerly 03.903) Winter Quarter
ECE 3517 and 3518 cover the same material with same prerequisites as ECE 3519, but in two QH courses. Prep. ECE 3241 and 3351.

ECE 3518 Information Theory B (2QH)
Spring Quarter
Continuation of ECE 3517.

ECE 3519 Information Theory (4QH)
Fall Quarter
Information theoretic viewpoint of a communication system. Concepts, definitions and results concerning mutual information and entropy for discrete and continuous alphabets. Channel capacity and the converse to the coding theorem for discrete memoryless channels; Blahut/Arimoto algorithm for calculating channel capacity. Random channel coding concepts, the random coding exponent and the coding theorem for a noisy channel. Discussion of the use of critical rate, cutoff rate and capacity for system design. Source coding of continuous and discrete sources; Rate-Distortion theory and variable-length source coding via Huffman's algorithm. Prep ECE 3241 and 3351.

ECE 3520 Special Topics in Communication Theory (2QH)
(formerly 03.908) Spring Quarter
Current aspects of communication theory not covered in previous courses. Subject matter may change from year to year. Prep: ECE 3241 and 3351.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3521 Multidimensional Spectrum Estimation (2QH)

Spring Quarter

Introduction; stationary random fields and their spectrum representation; place waves and their frequency-wavenumber spectrum; conventional methods (FFT based) and m-d window functions; m-d maximum likelihood method of Capon; 2-d maximum entropy methods; the extendibility problem in spectrum estimation; m-d parametric models for spectrum estimation: separable methods, m-d AR methods, techniques based on minimum variance representations, 2-d ARMA methods; the m-d Prony and Pisarenko methods. Prep. ECE 3503 and 3508.

ECE 3522 Array Signal Processing (2QH)

Spring Quarter

Array systems: configurations, cost, complexity, narrowband and wideband systems; problem formulation; duality between spectrum estimation and array processing; array processing methods: beamforming, minimum variance distortionless, autoregressive, thermal noise, music; coherent vs. incoherent sources; adaptive array processing: sidelobe cancellation, interference rejection, LMS algorithm; wideband array processing techniques; applications to sonar, radar, geophysics and biomedicine. Prep. ECE 3321.

ECE 3523 Communication Systems (4QH)

(formerly 03.870) Fall Quarter

Primarily concerned with radio communication systems as used in terrestrial and space communication applications. Antenna gain, space loss, cosmic and atmospheric noise, and receiver noise are considered as factors influencing the signal-to-noise ratio in space and satellite repeater systems. Contemporary systems are discussed from the standpoint of signal spectrum, noise power and message ambiguity as exhibited at the output of the intermediate frequency receiver. The theoretical aspects of amplitude and angle modulation systems are introduced and extended to cover multiplex systems; signal-to-noise ratio analysis of frequency multiplex systems; time division multiplex systems. Coverage of digital systems will include sampling, aliasing, and PCM/FM. Bit stream organization for transmission will be considered. A PCM encoder will be discussed as a means of matching the bit stream to the bandwidth. Illustrative examples will be drawn from contemporary communications systems used on balloons, rockets, and satellite repeaters. Prep. ECE 3241 and ECE 3104 or equivalent.

ECE 3524 Communication Systems A (2QH)

(formerly 03.871) Fall Quarter

ECE 3524 and ECE 3525 cover the same material with the same prerequisites as ECE 3523, but in two 2QH courses.

ECE 3525 Communication Systems B (2QH)

(formerly 03.872) Winter Quarter

Continuation of ECE 3524. Prep. ECE 3524.

ECE 3527 Nonlinear Systems I (2QH)

(formerly 03.910) Fall Quarter, As Announced

Operators and functionals. Functional power series representation of nonlinear systems. Functional representation of the response of a nonlinear system when its input is either a constant, a sinusoid, or a transient. System transforms. Applications to the analysis and synthesis of nonlinear systems in terms of functional power series. Prep. ECE 3241 and ECE 3221.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3528 Nonlinear Systems II (2QH)
(formerly 03.911) Winter Quarter, As Announced
Nonlinear systems with random inputs. Functional representation of the response of a nonlinear system when its input is a random process. Orthogonal systems of functionals. Representation and analysis of nonlinear systems in terms of orthogonal systems of functionals. The optimum nonlinear filter, predictor, and general operator. Special classes of nonlinear systems. Determination of optimum nonlinear systems for generalized error criteria. Prep. ECE 3527.

ECE 3529 Nonlinear Systems III (2QH)
(formerly 03.912) Spring Quarter, As Announced
Functional analysis of systems characterized by nonlinear differential equations. Operator approach to system theory and its relationship to differential equation representations. The methods of iteration in nonlinear theory and its application to feedback systems. Prep. ECE 3528.

ECE 3530 Three-Dimensional Picture Processing (2QH)
(formerly 03.887) Spring Quarter, As Announced
The application of computer, optical, and analytic methods in abstracting geometrical information from pictures. Pictorial presentation of data trains into multidimensional pictures. Methods will be studied for reconstructing three-dimensional objects from two-dimensional pictures. Applications will be in the areas of X-ray analysis, radar target identification, microscopy, and sensory perception. Students will have the chance to pursue individual projects during the term. Prep. ECE 3321.

ECE 3531 Adaptive Signal Processing (4QH)
Fall Quarter
Introduction; Optimum filtering (Wiener-Kalman); Signal and system modeling using linear prediction; Adaptive filtering (FIR, IIR); Fast algorithms for Least Squares adaptive filters; Adaptive array processing; VLSI architectures for adaptive signal processing. Prep. ECE 3321.

ECE 3532 Adaptive Signal Processing A (2QH)
Fall Quarter
ECE 3532 and ECE 3533 cover the same material with the same prerequisites as ECE 3531, but in two 2 QH courses. Prep. ECE 3321.

ECE 3533 Adaptive Signal Processing B (2QH)
Winter Quarter
Continuation of ECE 3532. Prep. ECE 3532.

ECE 3534 Digital Processing of Speech Signals (4QH)
Spring Quarter
Analysis and recognition of speech using computer techniques. Introduction to speech physiology, linguistics, phonetics, and acoustics. Models of speech production. Short-term processing of speech - temporal features, Fourier analysis, applications. Theory of linear predictive coding and applications. Homomorphic analysis of speech and applications. Speech and speaker recognition. Prep. ECE 3321.

ECE 3535 Digital Processing of Speech Signals A (2QH)
Fall Quarter
ECE 3535 and ECE 3536 cover the same material with the same prerequisites as ECE 3534, but in two 2 QH courses. Prep. ECE 3321.

ECE 3536 Digital Processing of Speech Signals B (2QH)
Winter Quarter
Continuation of ECE 3535. Prep. ECE 3535.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3537 Multi-User Communication Systems (4QH)

Spring Quarter

Contention-free multiple-access techniques: frequency-division multiple-access (FDMA), time-division multiple-access (TDMA). Spread-spectrum multiple-access (SSMA) communications: Direct-sequence SSMA, frequency-hop SSMA, and hybrid SSMA systems. Communication networks: queuing theory, multiple-access with contention (ALOHA random-access and tree algorithms for random-access), network routing and flow control (quasi-static control versus dynamic control). An overview of the applications of multi-user communication systems: computer-communication networks, broadcast satellite systems, military communications, mobile radio communications, packet-radio communication networks, and fiber-optic local-area networks. Prep. ECE 3351.

ECE 3538 Multi-User Communication Systems A (2QH)

Winter Quarter

ECE 3538 and ECE 3539 cover the same material with the same prerequisites as ECE 3537, but in two 2 QH courses.

ECE 3539 Multi-User Communication Systems B (2QH)

Spring Quarter

Continuation of ECE 3538. Prep. ECE 3538.

ECE 3540 Digital Control Systems (4QH)
(formerly 03.8D6)

Winter Quarter

Analysis of linear discrete-time dynamic systems; discretization of continuous systems; sampling and aliasing. Design of digital control systems using transform techniques by discrete equivalent and direct design methods; root locus, Bode and Nyquist diagrams and Nichols charts. Multivariant digital control using state-space methods; pole placement, observer, and regulator design. Controller implementation issues: digital filter realizations, nonlinear effects due to quantization, roundoff, deadband, limit cycles. Selection of the sampling rate. Prep. ECE 3221 and 3381.

ECE 3541 Digital Control Systems A (2QH)
(formerly 03.8D4)

Fall Quarter

ECE 3541 and ECE 3542 cover the same material with the same prerequisites as ECE 3540, but in two 2QH courses.

ECE 3542 Digital Control Systems B (2QH)
(formerly 03.8D5)

Winter Quarter

Continuation of ECE 3541. Prep. ECE 3541.

ECE 3543 Stochastic Control Systems (4QH)
(formerly 03.965)

Fall Quarter

Presents the techniques and results of modern stochastic system theory: basics of continuous-time stochastic processes; Markov processes; diffusion processes and drift; solution concepts, Ito integrals and the Ito formula; fundamentals of martingales; stochastic stability; state estimation and nonlinear filtering; stochastic control; linear stochastic systems: the Kalman filter and LQG control; application areas. Prep. ECE 3241.

ECE 3544 Stochastic Control Systems A (2QH)
(formerly 03.963)

Fall Quarter

ECE 3544 and ECE 3545 cover the same material with the same prerequisites as ECE 3543, but in two 2QH courses.

ECE 3545 Stochastic Control Systems B (2QH)
(formerly 03.964)

Winter Quarter

Continuation of ECE 3544. Prep. ECE 3544.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3546 Advanced Topics in Stochastic and Nonlinear Systems (4QH)
Winter Quarter
Current research topics in stochastic systems and nonlinear dynamics. Areas to be covered will be chosen from the following: Large deviations and stochastic optimization. Stochastic stability. Global dynamics, bifurcations and singular perturbations. Nonlinear circuit examples. Prep. ECE 3543

ECE 3547 Advanced Topics in Stochastic and Nonlinear Systems A (2QH)
Winter Quarter
ECE 3547 and ECE 3548 cover the same material with the same prerequisites as ECE 3546, but in two 2QH courses.

ECE 3548 Advanced Topics in Stochastic and Nonlinear Systems B (2QH)
Spring Quarter
Continuation of ECE 3547. Prep. ECE 3547.

ECE 3560 Acoustics I (2QH)
(formerly 03.817) Fall Quarter
The wave theory of sound. Radiation, reflection, and transmission phenomena. Distributed system analogies, and sound measurements. Prep. ECE 3341.

ECE 3561 Acoustics II (2QH)
(formerly 03.818) Winter Quarter
Speech and hearing, microphones and loudspeakers, guided waves, room acoustics. Environmental acoustics. Prep. ECE 3560.

ECE 3562 Acoustics III (2QH)
(formerly 03.819) Spring Quarter
Scattering and diffraction. Effects of viscosity and heat conduction. Finite amplitude and shock waves. Introduction to underwater sound. Prep. ECE 3561.

ECE 3563 Radar Systems I (4QH)
(formerly 03.865) Winter Quarter
Emphasis on the systems aspects of radar engineering. Topics covered include basic theory of radar detection, measurement of range, angle, and Doppler shift; classes of radar systems; types of radar noise; components of a radar system; matched filters and correlation receivers as applied to radar systems; fundamental ideas of radar system analysis. In-depth study of search radar theory; maximum likelihood estimation approach to measurement of radar target parameters; resolution and ambiguity functions applied to radar; radar parameter uncertainty principles. Prep. ECE 3241.

ECE 3564 Radar Systems I-A (2QH)
Fall Quarter
ECE 3564 and ECE 3565 cover the same material with the same prerequisites as ECE 3563, but in two 2QH courses. Prep. ECE 3241.

ECE 3565 Radar Systems I-B (2QH)
(formerly 03.866) Winter Quarter
Continuation of ECE 3564. Prep. ECE 3564.

ECE 3566 Radar Systems II (2QH)
(formerly 03.867) Spring Quarter
Advanced topics in radar systems engineering. Topics to be covered include: design considerations for multistatic radar systems, synthetic aperture radars; tracking systems; radar waveform synthesis; multifunction array radar techniques and selected topics in radar sensing techniques and devices. Prep. ECE 3563 or 3565.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3571 Fourier Optics (4QH)

Fall Quarter

This course covers: optical diffraction and imaging problems as linear systems; necessary tools of Fourier analysis and linear systems analysis which occur when solving the scalar wave equation; waves and their properties; reflection, refraction, polarization, and propagation of waves; foundations of scalar diffraction theory -- including Fresnel and Fraunhofer diffraction, interferometry, division of amplitude, division of wavefront, interferometric instrumentation, Fourier transforming, image properties of lenses, coherent and incoherent imaging; and advanced topics in the application of communication theory to optical problems, transfer and spread functions, spatial filtering, and holography. Prep. ECE 3581.

ECE 3572 Fourier Optics I-A (2QH)

Winter Quarter

ECE 3572 and ECE 3573 cover the same material with the same prerequisites as ECE 3571, but in two 2QH courses. Prep. ECE 3581 or 3582.

ECE 3573 Fourier Optics I-B (2QH)

Spring Quarter

Continuation of ECE 3572. Prep. ECE 3572.

ECE 3574 Fourier Optics II (2QH)
(formerly 03.983)

Fall Quarter

Covers current topics of interest in Fourier optics and optical instrumentation. Application of coherence phenomena to optical instrumentation such as microdensitometers, microscopes, viewers, cameras, spectraphotometric and interferometric instruments; applications of holography, optical data processing and computing, holographic memories, optical modulation, noise and its effects on data collection, synthetic aperture optics and medical application of laser optics. Prep. ECE 3573 or 3571.

ECE 3576 Lasers I (2QH)
(formerly 03.806)

Fall Quarter

Review of basic optical principles and atomic physics; introduction to optical coherence; models for the interaction of electromagnetic radiation with matter; a general description of lasers is given. Prep. ECE 3341.

ECE 3577 Lasers II (2QH)
(formerly 03.807)

Winter Quarter

Laser threshold and rate equations; elementary resonator theory and fabrication; giant pulse operation; specific solid-state, liquid, and gas lasers; and laser systems. Prep. ECE 3576.

ECE 3578 Lasers III (2QH)
(formerly 03.808)

Spring Quarter

Applications of lasers and laser systems for a variety of engineering and basic science disciplines; specific laser optoelectronic devices. Prep. ECE 3577.

ECE 3579 Optoelectronics and Fiber Optics (2QH)

Winter Quarter

Overview and analysis of the various elements and their characteristics which are utilized in optical communication systems, including elements which generate, transfer, and detect optical signals. Topics include resonance and guiding phenomena, semiconductor physics, LED's, lasers, diode detectors, optical waveguide theory and design, optical communication systems criteria. Prep. ECE 3580.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3580 Electro-Optics I (2QH)
(formerly 03.914) Spring Quarter
Survey of the basic concepts necessary for understanding and evaluating the optics involved in electro-optical systems. The optical system as a linear system; matrix methods; diffraction and interference; imaging and aberrations. Prep. Bachelor of Science Degree in Engineering or Physics.

ECE 3581 Electro-Optics II (2QH)
(formerly 03.915) Fall Quarter
Survey of the basic concepts necessary for understanding electro-optical devices. Wave propagation in isotropic and nonisotropic media; optics of crystals; polarization; optical resonators; guided waves; modulators and detectors; thin film optics. Prep. ECE 3580.

ECE 3582 Electro-Optics (4QH)
Spring Quarter
This course covers the same material as in ECE 3580 and 3581. Prep. BS in Engineering or Physics.

ECE 3583 Optical Properties of Matter I (2QH)
(formerly 03.921) Fall Quarter
Optics of crystals; classification and effects of crystal symmetry on optical properties; classical description of wave propagation in crystals; applications of the theory to modulation, pulse generation, nonlinear optics. Prep. Bachelor of Science Degree in Engineering or Physics.

ECE 3584 Optical Properties of Matter II (2QH)
(formerly 03.922) Winter Quarter
Introduction to electro-optical and magneto-optical effects in material media; linear and nonlinear optical materials; elasto-optic and acousto-optical materials; polarization and propagation effects; modulation. Prep. ECE 3583.

ECE 3585 Optical Properties of Matter III (2QH)
(formerly 03.923) Spring Quarter
Thin films and optical fibers; multilayer filters; dichroics; integrated optics. Prep. ECE 3584.

ECE 3586 Principles of Optical Detection (4QH)
Spring Quarter
The emphasis of this course is on the detector as a component of an optical system. Topics include the laws governing radiation and radiometry, properties of real radiation sources, detailed descriptions of detection devices, noise, contrast, and MTF, imaging and ranging devices, electro-optical detector systems analysis. It also includes practical consideration in real detectors, resolution and recognition of signals, heterodyne detection, sub-nanosecond pulse detection, and calibration of electro-optical detectors. Prep. BS Degree in Engineering or Physics

ECE 3587 Principles of Optical Detection A (2QH)
(formerly 03.981) Winter Quarter
ECE 3587 and 3588 cover the same material with the same prerequisites as ECE 3586, but in two 2QH courses. Prep. BS Degree in Engineering or Physics.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3588 Principles of Optical Detection B (2QH)
(formerly 03.982) Spring Quarter
Continuation of ECE 3587. Prep. ECE 3587.

ECE 3589 Optical Storage and Display (2QH)
(formerly 03.913) Fall Quarter
Survey of materials and methods for the storage and display of information. Topics included are: photographic film, holograms, storage tubes, magneto-optical films, photochromic materials, electro-optical crystals, evaporated thin films and liquid crystals. Prep. Bachelor of Science in Engineering or Physics.

ECE 3590 Optical Instrumentation Design (2QH)
(formerly 03.980) Fall Quarter
An introduction to the design of optical instrumentation. Principles and basic concepts of optical systems. In sequence the topics are: introduction, mechanical shock and vibration, kinematic designs; application of third order aberrations, simple optical ray tracing, optical testing, tolerances, optical instrumentation, philosophy, functional design, design for quantity production, quality assurance, "special order" design, industrial design, examples and exercises. Prep. Bachelor of Science in Engineering or Physics.

ECE 3591 Spectroscopic Instrumentation (2QH)
(formerly 03.984) Winter Quarter
Survey of optical instrumentation employed in analysis and control situations; modern methods of spectrometry and interferometry; optimization of analytical systems; topics in electron spectroscopy, X-ray spectroscopy, microwave spectroscopy, and related fields. Prep. ECE 3581.

ECE 3592 Remote Sensing (2QH)
(formerly 03.886) Spring Quarter, As Announced
Electromagnetic fundamentals related to passive and active remote sensing of the earth. Geophysical exploration techniques. Radar fundamentals and radar scattering. Instrumentation and data processing. Prep: ECE 3341.

ECE 3593 Plasma Engineering (4QH)
(formerly 03.800) Fall Quarter, As Announced
Overview of the basic principles and applications of plasma and gaseous discharges. The topics include gas kinetics, interaction of electrons and ions with static and rf fields as well as wave propagation in plasmas. Applications in material processing, space exploration and microwave devices will also be discussed. Prep. ECE 3341.

ECE 3594 Plasma Theory (4QH)
(formerly 03.803) Winter Quarter, As Announced
Introduction to the basic theory of gaseous discharges. Fluid and kinetic description of collisionless and collisional plasmas with and without magnetic field effects. Emphasis will be placed on linear stability analysis although nonlinear effects will also be discussed. Prep: ECE 3341.

ECE 3595 Plasma Theory A (2QH)
(formerly 03.801) Winter Quarter, As Announced
ECE 3595 and ECE 3596 cover the same material with the same prerequisites as ECE 3594, but in two 2QH courses.

ECE 3596 Plasma Theory B (2QH)
(formerly 03.802) Spring Quarter, As Announced
Continuation of ECE 3595. Prep. ECE 3595.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3600 Microwave Properties of Materials (4QH)

Fall Quarter

General dielectric and magnetic properties of materials; Tensor properties of dielectric and magnetic materials; Special microwave properties of thin film materials; Experimental techniques developed in the characterization of microwave materials. Prep. ECE 3102 and ME 1386 or equivalent.

ECE 3601 Microwave Properties of Materials A (2QH)

Fall Quarter

ECE 3601 and ECE 3602 cover the same materials with the same prerequisites as ECE 3600, but in two 2 QH courses. Prep. ECE 3102 and ME 1386 or equivalent.

ECE 3602 Microwave Properties of Materials B (2QH)

Winter Quarter

Continuation of ECE 3601. Prep. ECE 3601.

ECE 3603 Propagation in Artificial Structures (4QH)

Winter Quarter, As Announced

Effective dielectric and permeability constants in composite materials at high frequencies; Electromagnetic wave propagation in electrical and magnetic anisotropic media; magnetostatic and magneto-elastic wave propagation in single layer; Electromagnetic wave propagation in multi-layers. Prep. ECE 3102 or equivalent.

ECE 3604 Propagation in Artificial Structures A (2QH)

Winter Quarter, As Announced

ECE 3604 and ECE 3605 cover the same material with same prerequisites as ECE 3603, but in two 2 QH courses. Prep. ECE 3102 or equivalent.

ECE 3605 Propagation of Artificial Structures B (2QH)

Spring Quarter, As Announced

Continuation of ECE 3604. Prep. ECE 3604.

ECE 3606 Applications of Plasma Engineering (4QH)

Spring Quarter, As Announced

Basic operational principles of microwave electron devices, the theory of electric domain formation, free electron and gaseous lasers, particle beam accelerators and radiation sources. Particular topics include both classical microwave devices such as magnetrons, gyrotrons and crossed-field amplifiers, and solid state devices such as Gunn diodes and Impatt diodes. Prep. ECE 3593.

ECE 3607 Applications of Plasma Engineering A (2QH)

Winter Quarter, As Announced

ECE 3607 and ECE 3608 cover the same material with the same prerequisites as ECE 3606, but in two 2 QH courses. Prep. ECE 3593

ECE 3608 Applications of Plasma Engineering B (2QH)

Spring Quarter, As Announced

Continuation of ECE 3607. Prep. ECE 3607

ECE 3610 Electronics of Analog Signal Processing (4QH)

(formerly 03.8E3) Spring Quarter, As Announced

Analog signal acquisition and processing utilizing state of the art devices and circuit techniques such as adaptive filters in sampled data systems, CZTs for spectral analysis, correlated double sampling for improved S/N ratios and solid state imaging systems. Linear and nonlinear processing with MOS, bipolar and CTDs such as CCDs and SAWs. Attention given to analog vs. digital approaches for implementation of similar applications, i.e., bandwidth requirements, throughput, accuracy, cost, etc. Prep. ECE 3331 and ECE 3384.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3611 Electronics of Analog Signal Processing A (2QH)
(formerly 03.8E1) Fall Quarter, As Announced
ECE 3611 and ECE 3612 cover the same material with the same prerequisites as ECE 3610, but in two 2QH courses.

ECE 3612 Electronics of Analog Signal Processing B (2QH)
(formerly 03.8E2) Winter Quarter, As Announced
Continuation of ECE 3611. Prep. ECE 3611.

ECE 3613 Microwave Semiconductor Devices and Circuits (4QH)
(formerly 03.8H3) Spring Quarter, As Announced
S parameter theory. Waveguide junctions. Microstriplines and coplanar waveguides. Principles of operation of transferred electron devices and avalanche transit time devices such as Gunn diodes, IMPATTS and TRAPATTS. Parametric Devices. Microwave transistors such as bipolar transistors and field effect transistors. Microwave circuit characterization. Design of amplifiers and oscillators. Prep. ECE 3341 and 3344.

ECE 3614 Microwave Semiconductor Devices and Circuits A (2QH)
(formerly 03.8H1) Fall Quarter
ECE 3614 and ECE 3615 cover the same material with the same prerequisites as ECE 3613, but in two 2QH courses.

ECE 3615 Microwave Semiconductor Devices and Circuits B (2QH)
(formerly 03.8H3) Winter Quarter
Continuation of ECE 3614. Prep. ECE 3614.

ECE 3616 Active Network Synthesis and Design (4QH)
(formerly 03.845) Fall Quarter, As Announced
Multiloop feedback techniques are developed and applied to integrated circuit designs such as three-stage Op-Amp realizations and minimum sensitivity amplifiers. Application of these circuits in continuous-time and switched-capacitor filters are treated. Single-active biquadratic filter sections of Sallen and Key and Friend-Delyannis are developed. Multiloop and multiple-active element realizations such as the generalized impedance converter (GIC), frequency-dependent negative resistance (FDNR), follow-the-leader (FLF) and leap-frog (LF) structures are discussed. Design considerations include sensitivity, yield factors, gain-bandwidth product and the approximation problem. MOS switched-capacitor realizations of basic filter structures are developed. Prep. ECE 3331.

ECE 3617 Active Network Synthesis and Design A (2QH)
(formerly 03.843) Fall Quarter, As Announced
ECE 3617 and ECE 3618 cover the same material with the same prerequisites as ECE 3616, but in two 2QH courses. Prep. ECE 3331.

ECE 3618 Active Network Synthesis and Design B (2QH)
(formerly 03.845) Winter Quarter, As Announced
Continuation of ECE 3617. Prep. ECE 3617.

ECE 3619 Network Synthesis (4QH)
(formerly 03.832) Fall Quarter, As Announced
Matrix circuit analysis including m-port parameter systems. Positive-real functions. Energy functions. Driving-point synthesis techniques for LC, RC, and RL networks. Driving-point synthesis of RLC networks. Properties of two-port networks. Two-port synthesis, including the parallel ladder realization. Lattice synthesis. Prep. BSEE or ECE 3100 and ECE 3101.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3620 Network Synthesis A (2QH)
(formerly 03.831) Winter Quarter, As Announced
ECE 3620 and ECE 3621 cover the same material with the same prerequisites as ECE 3619, but in two 2QH courses. Prep. ECE 3100 and 3101.

ECE 3621 Network Synthesis B (2QH)
(formerly 03.832) Spring Quarter, As Announced
Continuation of ECE 3620. Prep. ECE 3620.

ECE 3622 Special Topics in Electronics - Analog MOS LSI Circuits (2QH)
(formerly 03.862) Spring Quarter
Selected topics of practical importance in the design of analog MOS integrated circuits. Principal topics are: NMOS & CMOS technology and devices; MOS transistor analog switch; digital - analog converters; comparators; analog - digital converters; sampled analog filtering concepts; switched - capacitor filters. Prep. ECE 3331 and ECE 3384.

ECE 3623 Gate Array Design (4QH)
Fall Quarter
The design, simulation, verification, and implementation of a CMOS gate array. Description of the VAX based gate array design and logic simulator tools. Students will be given design examples of digital logic circuits which will be entered, verified, and simulated. A description of the GE CMOS Macrocell Circuit Library and an introduction to TEGAS Logic Simulator will be included. After the completion of this course the GE Microelectronics Center, at Research Triangle Park, North Carolina, will fabricate the chosen student gate array design projects which then can be tested and evaluated. Prep. ECE 3331.

ECE 3624 Gate Array Design - A (2QH)
Winter Quarter
ECE 3624 and ECE 3625 cover the same material with the same prerequisites as ECE 3623, but in two 2QH courses.
ECE 3625 Gate Array Design - B (2QH)
Spring Quarter
Continuation of ECE 3624. Prep. ECE 3624.

ECE 3626 Integrated Circuits Fabrication Processes I (4QH)
Winter Quarter
Overview of, and the principles underlying, the basic techniques and processes employed in the fabrication of modern integrated circuits. Topics covered include crystal growth and epitaxy, oxidation deposition, diffusion and ion implementation, and metalization. A discussion of how these processes are combined to yield the current technologies (bipolar, NMOS, CMOS, MESFET) will be undertaken. Prep. ECE 3384.

ECE 3627 Integrated Circuits Fabrication Processes I-A (2QH)
Winter Quarter
ECE 3627 and ECE 3628 cover the same material with the same prerequisites as ECE 3626, but in two 2 QH courses. Prep. ECE 3384.

ECE 3628 Integrated Circuits Fabrication Processes I-B (2QH)
Spring Quarter
Continuation of ECE 3627. Prep. ECE 3627.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3629 Integrated Circuit Fabrication Processes II (4QH)

Fall Quarter, As Announced

The goal of this course is to provide the student with knowledge of the state of the art microelectronic fabrication techniques. Advance topics include electron beam, ion beam and x-ray lithographic techniques as well as dry processes which include plasma etching, ion beam processes and reactive ion etching. The concept of gas and plasma kinetics will be introduced. The mechanisms of sputtering and plasma etching will be discussed. Future device development and processing requirements will be covered also. Prep. ECE 3626.

ECE 3630 Integrated Circuit Fabrication Processes II-A (2QH)

Fall Quarter, As Announced

ECE 3630 and ECE 3631 cover the same material with the same prerequisites as ECE 3629, but in two 2 QH courses. Prep. ECE 3626.

ECE 3631 Integrated Circuit Fabrication Processes II-B (2QH)

Winter Quarter, As Announced

Continuation of ECE 3630. Prep. 3630.

ECE 3632 Design and Analysis of Digital Integrated Circuits (4QH)

Winter Quarter, As Announced

The analysis and design of basic digital-integrated-circuit logic families are treated. Bipolar circuits, including advanced-Schottky TTL, emitter-coupled logic (ECL). Double-buffered CMOS and NMOS logic gates, including dynamic logic circuits such as domino logic, are covered. Memory cells and basic cells in logic arrays are treated. Design considerations include propagation delay, switching speed, fan-out and the effect of parasitics. Design techniques are correlated with computer simulations. Prep. ECE 3101 or equivalent.

ECE 3633 Design and Analysis of Digital Integrated Circuits A (2QH)

Winter Quarter, As Announced

ECE 3633 and ECE 3634 cover the same material with the same prerequisites as ECE 3622, but in two 2 QH courses. Prep. ECE 3101 or equivalent.

ECE 3634 Design and Analysis of Digital Integrated Circuits B (2QH)

Spring Quarter, As Announced

Continuation of ECE 3633. Prep. ECE 3633.

ECE 3635 Antennas and Radiation (4QH)

Spring Quarter

Fundamental properties of antennas; linear and aperture antennas including slot, horn and patch antennas; arrays; receiving antennas; and numerical methods in antenna analysis. Topics in radiowave propagation; antennas over plane and spherical earth; interference, diffraction, surface waves, ducting; scattering from terrain surfaces; other propagation topics as time permits. Prep. ECE 3341, 3344.

ECE 3636 Antennas and Radiation A (2QH)

Fall Quarter

ECE 3636 and ECE 3637 cover the same material with the same prerequisites as ECE 3635, but in two 2 QH courses. Prep. ECE 3341 and 3344.

ECE 3637 Antennas and Radiation B (2QH)

Winter Quarter

Continuation of ECE 3636. Prep. ECE 3636.

Note: to earn credit for a part A/part B course you must take both part A and part B.

ECE 3638 Microwave Electron Devices (4QH)

Fall Quarter

The fundamental principles and operation of the principle types of conventional (linear-beam and crossed-field) and novel (maser effect) devices will be presented. Interactions of non-relativistic and relativistic electron beams with electromagnetic fields. Linear-beam tubes (klystron, traveling wave tube, backward-wave amplifier and oscillator etc.) crossed-field tubes (magnetron, forward and backward cross-field amplifier, high-gain CFA, etc.). Maser-effect devices (cyclotron maser, gyrotron). Prep. ECE 3341.

ECE 3639 Microwave Electron Devices A (2QH)

Winter Quarter

ECE 3639 and ECE 3640 cover the same material with the same prerequisites as ECE 3638, but in two 2QH courses. Prep. ECE 3341.

ECE 3640 Microwave Electron Devices B (2QH)
Continuation of ECE 3639. Prep. ECE 3639.

ECE 3646 Multivariable Control Systems (4QH)

Fall Quarter

Mathematical preliminaries, polynomial and polynomial matrices; representations of linear multivariable system; matrix fraction description (MFD) and polynomial matrix description (PMD); responses of linear multivariable systems; controllability, observability and canonical forms; poles and zeros of multivariable systems; stability; realization problem; interaction control; state feedback and observer design; compensator design, stability and robustness; noninteraction control; frequency domain design techniques. Prep. ECE 3221 and 3381.

ECE 3647 Multivariable Control Systems A (2QH)

Fall Quarter

ECE 3647 and ECE 3648 cover the same material with the same prerequisites as ECE 3646, but in two 2 QH courses. Prep. ECE 3321 and 3381.

ECE 3648 Multivariable Control Systems B (2QH)

Winter Quarter

Continuation of ECE 3647. Prep. ECE 3647.

ECE 3797 Engineer Degree Thesis Continuation (0QH)
(formerly 03.9Z3) Any Quarter
Candidates to sign up for thesis continuation if their thesis is not completed after they have registered for 3 consecutive quarters or 10 QH of EE degree thesis. Continuous registration is required until the candidate graduates.

ECE 3798 Master's Continuation (0QH) Any Quarter
(formerly 03.9X1)

ECE 3799 PhD Thesis Continuation (0QH) Any Quarter
(formerly 03.9X4)

ECE 3860 Master's Thesis (8QH)
(formerly 03.995) Any Quarter
Analytical and/or experimental work conducted under the auspices of the department. Prep. Bachelor of Science degree in Engineering or Science.

ECE 3861 Master's Thesis (4QH) Any Quarter

ECE 3862 Master's Thesis (2QH) Any Quarter

ECE 3870 Engineer Degree Thesis (8QH)
(formerly 03.9Z2) Any Quarter
Analytical and/or experimental work conducted under the auspices of the department. Minimum of 4 QH, maximum of 8 QH allowed per quarter. Prep. Admission to Engineer Degree Program.

ECE 3871 Engineer Degree Thesis (4QH) Any Quarter

ECE 3872 Engineer Degree Thesis (2QH) Any Quarter

ECE 3880 Doctoral Thesis (0QH)
(formerly 03.996) Any Quarter
Theoretical and/or experimental work conducted under the auspices of the department. Prep. Passing of PhD Qualifying Exam.

ECE 3887 Master's Seminar I (2QH)
(formerly 03.990) Any Quarter
A library survey of a selected topic in the general field of electrical engineering with an oral presentation based on this survey. Participation in the departmental seminar program of guest lectures. Prep. Bachelor of Science degree in Engineering or Science.

ECE 3888 Master's Seminar II (2QH)
(formerly 03.991) Any Quarter
The preparation of a research paper suitable for publication in a professional journal, plus an oral presentation of this report. Prep. ECE 3887.

ECE 3889 Doctoral Seminar (0QH)
(formerly 03.993) Any Quarter
This requirement will be satisfied by the student presenting a seminar to the Electrical Engineering Department on a subject related to his/her PhD thesis. The thesis supervisor will coordinate the seminar. Prep. Passing of PhD Qualifying Exam.

ECE 3892 Doctoral Reading (0QH)
(formerly 03.997) Any Quarter
Material approved by the candidate's advisor. (Only S or F grades will be assigned for this course.) Prep. Passing of PhD Qualifying Exam.

ECE 3893 Special Problems in Electrical Engineering (2QH)
(formerly 03.998) Any Quarter
Theoretical or experimental work under individual faculty supervision. Prep. Consent of Department Chairman. (4QH equivalent is course ECE 3896)

ECE 3894 Engineer Degree Reading (4QH) Any Quarter
(formerly 03.9Z1)
To be taken upon completion of 30 QH of satisfactory course work. No credits towards course requirements is given. Minimum of 4 QH, maximum of 8 QH allowed per quarter.

ECE 3895 Engineer Degree Reading (8QH) Any Quarter

ECE 3896 Special Problems in Electrical Engineering (4QH) Any Quarter

OINT 3250 Engineering and Medicine I (2QH)
(formerly 93.901) Fall Quarter
The intersection of technology with medicine; historical development of bioengineering profession; its impact on society; study of activities embraced by the profession today; educational, training, and career opportunities in clinical, biomedical, and medical Engineering for individuals at the BS, MS, and PhD levels; future goals of engineering in biology and medicine; and issues basic to the relationship between new medical technology and the efficiency and effectiveness of the health care system. Prep. Permission of instructor

OINT 3251 Biomedical Applications of Heat and Mass Transfer (2QH)
(formerly 93.911) Winter Quarter
Bioheat equation; thermal transport in living systems, thermal properties; thermal techniques in the measurement of blood flow; applications of heat transfer in medicine including hyperthermia for cancer therapy, hypothermia for tissue and organ preservation and cryosurgery, thermal sources for implantable artificial heart; andthermography in cancer detection. Prep. Permission of instructor

OINT 3252 Selected Topics in Bioengineering (2QH)
(formerly 93.912) Spring Quarter
Study of biomedical engineering appropriate to topics selected from fields of biomaterials, nuclear medicine, radiation diagnosis and therapy, biological transport processes, artificial organs, rehabilitation engineering, and microprocessor based clinical instruments. Introduction to medical technology assessment. Prep. OINT 3250 or permission of instructor.

DEPARTMENT OF INDUSTRIAL ENGINEERING AND INFORMATION SYSTEMS

The Department of Industrial Engineering and Information Systems offers the following graduate degrees: Master of Science in Industrial Engineering (MSIE); Master of Science in Engineering Management (MSEM); Master of Science in Information Systems (MSIS); Industrial Engineer; and Doctor of Philosophy. The department is also the major contributor to the Engineering Software Design concentration of the interdisciplinary Computer Systems Engineering degree (see Computer Systems Engineering Section of this catalog). Students pursuing a Master of Science in Industrial Engineering or Engineering Management may follow a general program with no concentration or choose one of the following areas of concentration: Computer and Information Systems; Manufacturing Systems; Operations Research, or Quality Control and Reliability Analysis.

The MSIE and MSEM programs may be taken by full-time students on a continuous basis or under the cooperative or sponsorship (intern) plans. These programs may be pursued also on a part-time basis, with courses being offered in the evening.

The MSIS program may be pursued by students who are currently employed in the information systems profession on a part-time or full-time basis, but all other applicants are expected to enroll as full-time students for two quarters and then participate in the graduate cooperative education program by taking a position in information systems for a minimum of six months. During this time, candidates may continue to take courses in the evening graduate program to further meet the degree requirements.

Master of Science Degree Requirements for MSIE and MSEM

A minimum of forty quarter hours of graduate level credit is required for any of the Master of Science programs in the Industrial Engineering and Information Systems Department, including up to six quarter hours of prerequisite or advanced undergraduate courses as electives.

Up to six quarter hours may be elected in other graduate schools with the approval of the student's faculty advisor and the Director of the graduate school offering the desired course. The amount of credit applied toward the degree will be established by the student's advisor.

It is expected that students entering the MSIE and MSEM programs have an adequate background in the following areas: Engineering Economy; Operations Research; Probability and Statistics; Human Factors (Industrial Engineering only); and Computer Programming. If the admissions committee concludes that a student has not had sufficient preparation in these areas, they may specify prerequisite courses as part of the degree requirements. No more than six quarter hours of this prerequisite work can be applied as electives towards the required 40 hours of graduate work for the Master of Science degree.

Elective Courses

Any non-prerequisite course can be taken as an elective. In the IE/IS Department all prerequisite courses begin with 31XX.

MSIE & MSEM Prereq. Courses (primarily for non-IE degree holders) Credits

IIS 3102	Introduction to Human Factors Engineering	2
IIS 3103	Basic Operations Research	4
IIS 3113	Basic Probability and Statistics	4
IIS 3100	Basic Engineering Economy	2
IIS 3101	Industrial Accounting for Engineers	2
Higher Level Language (a structured language is required for the C&IS concentration, e.g. IIS 3106 (Pascal), IIS 3115 or IIS 3117 (Modula - 2))		

Master of Science in Information Systems

The program consists of courses which help students develop both management and information skills. The former category includes courses such as Planning and Managing IS Development, Accounting, and Management Science, while the latter covers topics such as Computer Technology, Data Base Management, Operating Systems, and Software Design. The prerequisite set of courses (totaling 24 credits) will be required for students, or waived, depending on their particular academic background and undergraduate experience. It is expected that students beginning this program will have an adequate background in the following areas: calculus, probability, accounting, and programming languages (including Pascal, COBOL and an Assembly Language). Deficiencies in this background are removed by taking the appropriate prerequisite courses described below.

Based upon the recommendation of the Graduate School and the advisor, a student may be required to take all or some of the following prerequisite courses. However, no more than six hours of graduate credit from the prerequisite courses can be applied to the minimum degree requirements of forty quarter hours. Students must obtain advisor approval for selection of MSIS and other electives.

Prerequisite Courses		Credits
MTH 3211, 3212, 3213	Elements of Math for Info Sys I, II, II	2 each
IIS 3101	Industrial Accounting for Engineers	2
IIS 3111	Principles of COBOL	2
IIS 3112	Quantitative Methods for Information Systems	4
IIS 3113	Basic Probability & Statistics	4
IIS 3106	Elements of Structured Programming (Pascal)	2
IIS 3116	Assembly Language	4

Course Requirements

Core Courses	24 QH
MSIS Elective Courses	8 QH
Open Electives	8 QH
Minimum Quarter Hours Required*	40 QH

*include maximum of 6 QH of prerequisite courses

MSIS Core Courses-24 QH		
IIS 3604	Data Structures & Intro to Data Base Mgt	4
IIS 3607	Operating Systems & Systems Software	4
IIS 3610	Computer Architecture	4
IIS 3615	Analysis and Design of Computer Info Sys	4
IIS 3622	IS in a Microcomputer Environment	4
IIS 3628	Data Base Management Systems	4
MSIS Elective Course-Select 8 QH		
IIS 3218	Planning & Management Information Sys. Dev	4
IIS 3307	Introduction to Microprocessors	2
IIS 3308	Microcomputer Applications	2
IIS 3623	File Processing	2
IIS 3624	Software Engineering I	4
IIS 3625	Software Engineering II	4
IIS 3626	Networks and Telecommunications	4
ME 3500	Computer Aided Graphics & Design	4

Master of Science in Industrial Engineering

The MSIE degree requires either an eight quarter hour thesis or a four quarter hour special project. Arrangements for and approval of the topic for the special project or thesis must be made with a member of the full-time faculty of the department. All MSIE students will take the core courses shown below. Equivalent substitutions must be approved by a petition.

	With Thesis	With Project
Core Courses	20 QH	20 QH
Electives	12 QH	16 QH
Thesis or Project	8 QH	4 QH
Minimum Quarter Hours Required	40 QH	40 QH

Required Core Courses		Credits
IIS 3304	Production Analysis	4
IIS 3503	Simulation Methodology and Applications	4
IIS 3514	Advanced Operations Research	4
IIS 3522	Systems Engineering Design and Analysis	4
IIS 3523	Applied Statistics	4

The remaining coursework is satisfied by elective courses. A student may opt for a concentration in Computers and Information Systems, Human Factors, Manufacturing Systems, or Operations Research and Reliability Analysis by taking the required courses for the elective concentration.

Master of Science in Engineering Management

The core course requirements for the Engineering Management program are listed below:

Core Courses	24 QH
Electives	16 QH
Minimum Quarter Hours Required	40 QH

Required Core Courses		Credits
IIS 3204	Engineering/Organizational Psychology	4
IIS 3207	Financial Management	4
IIS 3217	Engineering Project Management	4
IIS 3503	Simulation Methodology and Applications	4
IIS 3523	Applied Statistics	4
IIS 3615	Analysis and Design of Computer Information Systems	4

The remaining coursework is satisfied by elective courses. A student may opt for a concentration in Computers and Information Systems, Manufacturing Systems, Operations Research, or Quality Control and Reliability Analysis by taking the required courses for the elective concentration.

Required Courses for Elective Concentrations

		Credits
Computer and Information Systems-8 QH		
IIS 3604	Data Structures and Introduction to Data Base Mgt	4
IIS 3628	Data Base Management Systems	4
IIS 3615	Analysis & Design of Computer Information Systems (MSIE only)	4
Manufacturing Systems-12 QH (All 3 courses below are mandatory)		
IIS 3309	Computer Methods in Manufacturing	4
IIS 3310	Manufacturing Methods and Processes	4
IIS 3311	Computer-Aided Manufacturing	4
Operations Research-12QH		
IIS 3514	Advanced Operations Research (for MSEM only)	4
Two out of the three following courses:		
IIS 3524	Multi-Criteria Decision Making	4
IIS 3513	Network Analysis and Advanced Linear Programming	4
IIS 3512	Stochastic Modeling & Queueing Systems	4
Quality Control and Reliability Analysis-12QH		
IIS 3525	Intro. to Reliability and Risk Assessment	4
IIS 3518	Statistical Quality Control	4
IIS 3535	Reliability Engineering & Testing	4

The Industrial Engineer Degree

This degree is designed for those who wish to undertake graduate study beyond the Master of Science degree which is less extensive and more applied than that required for the doctorate. The program leading to the Industrial Engineer degree permits a candidate to pursue a course of study at the upper graduate level which will help the student develop in-depth knowledge in selected Industrial Engineering techniques, and the ability to apply these techniques to complex problems in a real-world setting. The candidate will work closely with a faculty advisor throughout the program.

Qualifications, Degree Candidacy, and Examinations

Upon acceptance, a student is classified as a degree candidate. A 3.00 grade point average must be maintained in order to qualify for the degree. A final oral examination for defense of the written report of the Industrial Engineer degree project conducted by the student's project committee is also a requirement for the degree.

Course Requirements

A minimum of 40 quarter hours beyond the Master of Science degree is required. Normally ten quarter hours of credit out of the 40 will be granted for work on the Industrial Engineering degree project. A minimum of 20 quarter hours must be taken in Industrial Engineering.

Language Requirements

There is no language requirement for the Industrial Engineer degree.

Residence Requirement

Since the Industrial Engineer degree project requires the structuring and solving of a complex problem, residence requirements will be satisfied by an arrangement, approved by the advisor, which allows the student to devote a sufficient portion of his or her time to the project to permit an intensive problem-solving experience.

Engineer Degree Project

To be awarded the degree of Industrial Engineer, the candidate must complete, in addition to the required course work, a project demonstrating a high level of competence in structuring and solving a complex real-world problem. The problem addressed in this project is of an applied nature. Where applicable, an on-going organization will be used as the setting. The work should lead to a solution which satisfies all technological and organizational constraints, and is therefore capable of being implemented. The topic will be selected by the student and the faculty advisor. Normally, a project committee of three faculty members will be appointed.

The Doctor of Philosophy Degree

The Doctoral Program in IE/IS requires the successful completion of the following five-step procedure: (i) admission, (ii) research and course preparation, (iii) the doctoral qualifying exam, (iv) the doctoral thesis, and (v) the doctoral defense.

I. Admission

Prospective candidates are required to have completed the equivalent of an M.S. program in Industrial Engineering, or a related engineering/scientific field. A minimum of 3.40 grade point average out of 4.0 over the course of the applicant's graduate career is required. Acceptably strong letters of recommendation from two or more faculty familiar with the applicant's capability for graduate study must also be provided.

II. Research and Course Preparation

Upon admission, the student will complete a research project, if he/she has not completed a master's level research thesis. All graduate course requirements must also be met for the particular research concentration (viz., Operations Research, Manufacturing Systems, Computer and Information Systems, or Quality Control & Reliability Analysis) before the student can take the doctoral qualifying examination.

III. Doctoral Qualifying Examination

The doctoral qualifying examination is administered by the department as required, usually in the Fall and Spring Quarters. It is a two part examination. A written examination covers both the core curriculum of the department and the student's chosen area of research specialization. This is followed by an oral examination. Upon passing the qualifying examination, the student becomes a doctoral candidate.

IV. Doctoral Thesis

The doctoral thesis consists of a research effort, which is original, advanced work that makes a significant contribution to the candidate's field of research. The candidate's thesis committee who will review the written report will be chaired by a full-time IE/IS faculty member, and it must consist of at least three persons, of whom at least two are full-time IE/IS faculty members.

V. Doctoral Defense

The doctoral defense consists of an oral presentation and question/answer period in which the candidate presents and defends his/her doctoral research work. The defense will be attended by the candidate's doctoral thesis committee and other interested members of the university community. Determination of adequate defense of the work will be made by the committee.

Faculty

Wilfred P. Rule, Acting Chairman

Professors

Cullinane, Thomas P., PhD, Virginia Polytechnic and State University; manufacturing systems, facilities planning, industrial hygiene

Freeman, David R., PhD, Stanford University; engineering economy, computer-aided manufacturing

Mourant, Ronald R., PhD, Ohio State University; simulation, human-computer interaction

Rule, Wilfred P., MS, MIT; management information systems

Associate Professors

Fard, Nassar, PhD, University of Arizona; reliability analysis

Gupta, Surendra M., PhD, Purdue University; simulation, operations research, production systems

Heising, Carolyn D., PhD, Stanford University; reliability analysis, probabilistic risk assessment

Kokar, Mieczyslaw, PhD, Technical University of Wroclaw; artificial intelligence, operating systems

Melachrinoudis, Emanuel S., PhD, University of Massachusetts; operations research,manufacturing systems

Perry, Ronald F., PhD, University of Michigan; management information systems, simulation

Assistant Professors

Kim, Jason J., PhD, University of Tennessee; Industrial Engineering

Rumpf, David L., PhD, University of Massachusetts; statistics, operations research, management information systems

Staknis, Mark E., PhD, University of Virginia; Computer Science

Voland, Gerard G.S., MS, UCLA; engineering design, control theory, rehabilitation engineering

Lecturer

Leibowitz, Sue, MS, Northeastern University, computer programming and computers as an instructional aid

Instructor

Pike, Richard, MBA, Northeastern University, organizational behavior, engineering economy

Advisors

MSIE & MSEM	
General	Prof. Cullinane, Prof. Gupta, Prof. Rule
Computer and Information Systems	Prof. Mourant
Operations Research & Reliability Analysis	Prof. Gupta, Prof. Heising, Prof. Melachrinoudis
Manufacturing Systems	Prof. Gupta, Prof. Goldman
MSIS	Prof. Perry
Software Engineering	Prof. Kokar (M-Z), Prof. Mourant (A-L)

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine what courses are actually offered in any given quarter and at what day and time.

IIS 3100 Basic Engineering Economy (2QH)
(formerly 05.808) Fall and Winter Quarters
Economic analysis in formulating business policies and selecting alternatives from possible engineering solutions to industrial problems, present worth, annual cost, and rate of return techniques using discrete compound interest calculations. Prep Bachelor of Science degree in Engineering or Science.

IIS 3101 Industrial Accounting for Engineers (2QH)
(formerly 05.810) Fall, Winter, and Spring Quarters
Introduction to basic accounting principles and procedures; use of accounting data as a management tool; a practical covering of basic cost accounting procedures related to materials, labor, and manufacturing expense cost control; job order, process, and standard cost systems.

IIS 3102 Introduction to Human Factors Engineering (2QH)
(formerly 05.851) Fall and Winter Quarters
A survey of the principal topics and areas of concentration in the field. Includes introductory concepts of sensory physiology and sensory performance; basic motor capabilities and limitations; concepts of the human as a processor of information; and methods of gathering human performance data. Normally the first course in the human factors areas for students without behavioral science background. Prep. IIS 3113 or permission of instructor.

IIS 3103 Basic Operations Research (4QH)
Winter and Spring Quarters
An introduction to the theory and use of deterministic and stochastic models to represent industrial operations. Models included are those of linear programming, dynamic programming, inventory control, waiting lines, and Markov Chains. Prep. IIS 3113.

IIS 3106 Elements of Structured Programming (2QH)
(formerly 05.920) Fall, Winter, and Spring Quarters
An introduction to the principles and techniques of top down structures programming. The host language is PASCAL and topics covered include assignment statements, logical expressions, control statements, data structures, recursion and pointers. Prep. Admission to Graduate Program.

IIS 3111 Principles of COBOL (2QH)
(formerly 05.939) Fall and Winter Quarters
Fundamentals of computer programming in COBOL. Topics include elementary computer functioning, program organization, input/output operations, arithmetic and data-handling verbs, and program logic development through the use of flow charts. Storage and manipulation of large data files on magnetic tape are introduced. No prior computer experience is required. Prep. Admission to Graduate School.

IIS 3112 Quantitative Methods for Information Systems (4QH)
Fall and Winter Quarters
An introduction to the theory and use of deterministic and stochastic models in the context of computer and information systems. Models included are linear programming, dynamic programming, Monte Carlo simulation, Gantt and Pert charts, multicriteria decision analysis and waiting lines. Emphasis of class examples will be on applications in a computer and information systems environment. Prep. IIS 3113.

IIS 3113 Basic Probability and Statistics (4QH)

Fall, Winter and Spring Quarters

Fundamental concepts of probability. Events, sample space, discrete and continuous random variables. Density functions, mass functions, cumulative probability distributions and moment generating functions. Expectation of random variables. Common discrete and continuous probability distributions including binomial, poisson, geometric, uniform, exponential and normal. Multivariate probability distributions, covariance and independence of random variables. Sampling and descriptive statistics. Parameter estimation, confidence intervals and hypothesis testing. Prep. Admission to Graduate Program.

IIS 3115 Modula-2 for Engineers (4QH)

Fall Quarter

The objectives of the course include: methods for solving problems on the computer, knowledge of the basic hardware/software of a computer system and proficiency in a high level programming language (Modula-2). The building blocks of Modula-2: data types, variable and constant declarations; enumerations, arrarys, sets, records, and pointers; input/output library functions. The control structures of Modula-2: procedures, modules and visibility control. Also covered are sequential and screen-oriented input/output; recursion, concurrency and low-level facilities; software design using structured charts. Prep. Admission to Graduate Program.

IIS 3116 Assembly Language (4QH)

Fall Quarter

The study of computer programming in an assembly language with emphasis on structured programming techniques, interrupt service routines, and input/output device drivers. Topics will also include elements of a mini/micro-computer system architecture, system resources, interrupts input/output interfaces, processor's instruction set and addressing modes. Students will use an assembler and a debugger on a computer system selected by the instructor to write and run assembly language programs. Possible computers to be used include the VAX family of mini-computers, 8088 and 80286-based micro-computers (IBM-PC family) or 6800-based micro-computers (Macintosh). Prep. Higher level language.

IIS 3117 Intensive Modula-2 (2QH)

Winter Quarter

Programming in Modula-2 for students who know another structured high-level language. Syntax and basic data and control structures: modules, procedures and visibility control; and overview of enumerations, arrays, records, sets and pointers. Basic input/output library functions; sequential and screen-oriented input/output. Recursion, concurrency and low-level facilities in Modula-2. Software design using structured charts. Prep. Structured high-level language.

IIS 3200 Organizational Perspectives and Project Management (4QH)

Spring Quarter

A survey of business organization, management and operation, including business responsibility to its employees, its product, the customer and the environment in which it operates. Planning, forecasting, and budgeting; the financial markets; investing and speculating will be covered, as well as the interaction of politics, government and government controls on the industrial enterprise. Prep. Admission to Graduate Program.

IIS 3204 Engineering/Organizational Psychology (4QH)

Fall Quarter

An analysis of the purpose and functioning of organizations as the basic networks for achieving goals through coordination of effort, communication, and responsibility. The role and function of engineering organizations based on modern behavioral science concepts. The application of psychology to industry relative to human relations, group dynamics, tests and measurements, personnel practices, training, and motivation. Prep. Admission to Graduate Program.

IIS 3205 Industrial Organizations (2QH)

Winter Quarter

IIS 3205 and IIS 3206 cover the same material as IIS 3204, but in two 2QH courses.

IIS 3206 Industrial Psychology for Engineers (2QH)

Spring Quarter

IIS 3205 and IIS 3206 cover the same material as IIS 3204, but in two 2QH courses. Prep. 3205.

IIS 3207 Financial Management for Engineers (4QH)

Fall and Winter Quarters

Study of the issues and processes of short-term financing on industrial firms; financial analysis of cases, supplemented by readings to develop familiarity with sources and uses of working capital as well as the goals and problems involved in its management. Also covered is the analysis necessary for such long-term financial decisions as issuance of stock or bonds; contracting of leases or loans, and financing of a new enterprise; mergers, capital budgeting, the cost of capital, and the valuation of a business. Prep. IIS 3101.

IIS 3216 Advanced Engineering Economy (2QH)

(formerly 05.809) Winter Quarter

Principal emphasis on the practical application of the techniques studied in basic engineering economy; problems of implementation through class discussion of cases and student projects; recent advances in the techniques of engineering economy, especially those relating to the consideration of uncertainties. Prep. IIS 3100.

IIS 3217 Engineering Project Management (4QH)

Winter and Spring Quarters

The optimization of schedules utilizing pertinent software tools such as the linear programming and project management packages will be undertaken. Other graphics software used to draw project diagrams such as Gantt charts, PERT diagrams, manpower loading charts and funding charts will be included. Determination of the critical path and comparison of actual performance with the planned schedule will be covered. The systems life cycle will be considered. Needs analysis, requirements definition, preliminary design, detailed design and implementation will be addressed in the context of project management. Prep. Admission to Graduate Program.

IIS 3218 Planning and Managing Information Systems Development (4QH)

Spring Quarter

The computer system development life cycle. Interactions between the system and the organization. Design parameters and tradeoffs. Planning for externalities. Individual and organizational aspects of human decision making. Systems approach to planning, management and control of effective information systems development. The course will be based on extensive use of case studies and will include some guest speakers. Prep. IIS 3615.

IIS 3219 Cost Accounting and Industrial Budgeting (4QH)

Fall and Spring Quarters

Cost accounting procedures are studied and evaluated in terms of being considered by the engineer for cost determination of alternative engineering proposals and for input into various budgeting plans which the engineer may become involved with. An introduction to the essentials of fixed and variable budgeting for production, inventory, sales, cash, capital and cost-volume profit analysis will be provided. Prep. IIS 3101.

IIS 3220 Development of Engineering Personnel (4QH)

Fall Quarter

The science and art of managing creative people employed in research, developmental, and engineering activities are considered with a view to understanding the problems encountered by such people and their managers in the course of their professional work. Attention is devoted to behavioral theories and their applications in the practice of management. Emphasis is placed on each student's own experiences as professionals or managers in diverse industrial settings. Prep. Admission to Graduate Program.

IIS 3302 Advanced Work Design (2QH)
(formerly 05.817) Spring Quarter
Basic philosophies of work design; implementation of work design concepts with case studies; study and analysis of models such as work sampling, sequence or flow of work models; repetitive and nonrepetitive work models, and work measurement models such as standard data; human factors in measuring operator performance; regression analysis approaches; emphasis on development of professional, analytical, and managerial skills and abilities at a systems level. Prep. Bachelor of Science degree in Engineering or Science.

IIS 3303 Product Design and Value Analysis (2QH)
(formerly 05.822) Winter Quarter
Study of design parameters and their effect on development, manufacturing and procurement; functional analysis of components and systems; complete projects and case studies are integrated in the course. Prep. Bachelor of Science degree in Engineering or Science.

IIS 3304 Production Analysis (4QH)
(formerly 05.823) Fall Quarter
Modern quantitative techniques of production planning and control considering deterministic and probabilistic models are presented. Topics include project planning, forecasting, aggregate planning and master scheduling, inventory analysis and control, materials requirement planning, job shop scheduling and dispatching problems. Prep. IIS 3103 and IIS 3113.

IIS 3305 Case Studies in Industrial Engineering (2QH)
(formerly (05.824) Spring Quarter
Formulation of problems and analysis of situations on topics such as work measurement, line balancing, plant layout, regression analysis, wage and salary administration, management information systems and network analysis. Class discussion and written analysis of a variety of cases are included. Prep. IIS 3304, IIS 3523.

IIS 3307 Introduction to Microprocessors(2QH)
(formerly 05.971) Winter Quarter
First course in advanced microprocessor systems introducing basic concepts of system architecture, interfaces and programming using modern 16- and 32-bit microprocessor families. CPU programming model, instruction set, addressing modes and exception processing. Privilege states, memory management, bus control. Principles of assembly language programming. Two microprocessor families: MC68000 and iAPX86. Prep. Structured higher level language.

IIS 3308 Microcomputer Applications (2QH)
(formerly 05.972) Spring Quarter
Introductory course on microcomputer applications in local networks. Multi-microcomputersystems, bus topology interconnection, communication architecture and protocols. Microcomputer-based local network nodes, local network model and protocol development examples. Token bus and collision detection protocols. Prep. Structured higher level language and IIS 3307 or equivalent.

IIS 3309 Computer Methods in Manufacturing (4QH)
(formerly 05.974) Fall Quarter
In depth coverage of the use of computers in selected areas of manufacturing systems design is presented. Possible topic areas are numerical control, MRP, process planning and control, and other important applications of computers to manufacturing systems. Prep. IIS 3311 or permission.

IIS 3310 Manufacturing Methods and Processes (4QH)
(formerly 05.975) Spring Quarter
The structures of polymers (thermoplastic, thermosetting and glasses). Manufacturing processes for polymers including thermoforming are included. Structure of metals, the manufacturing processes for metal forming are presented. Alloys and welding and brazing are also included. Prep. Bachelor of Science degree in Engineering or Science.

IIS 3311 Computer-Aided Manufacturing (4QH)
(formerly 05.980) Spring Quarter
A first course (overview) of computer aided manufacturing. Covers the areas that encompass the term CAM, i.e., group technology, material requirements planning, part coding and classification, numerical control, part programming and management systems. Broad coverage of each of the areas is given to allow the student to gain an appreciation of the coming review of the automated factory. Prep. Higher level language.

IIS 3312 Forecasting and Inventory Control (4QH)
Winter Quarter
Econometric methods of forecasting the demand for industrial products; emphasis on techniques applicable to individual companies and the total demand. The principal tool used is the mathematical model of the causal factors with special attention to determining the reliability of the model. The design and operation of inventory systems from a scientific management point of view, including both required theory and practical aspects. Subjects include inventory control models and techniques, production planning and control models and methods. Prep. IIS 3103 and IIS 3523.

IIS 3400 Human Factors Engineering (4QH)
Winter Quarter
Sensory motor and work environment considerations. Topics include the design of equipment and systems for human use, with the application of engineering psychology; visual and auditory presentation of information; human information processing and skilled task performance. The human as a work-performing, heat generating physiological engine, and the implied restrictions on the equipment and work place to provide occupational safety and effective man/machine performance. Prep. IIS 3102.

IIS 3403 Occupational Health and Safety (4QH)
Winter Quarter
Topics include safety responsibilities of management and employees; recognition of chemical, electrical, and mechanical hazards; principles of machine guarding; accident investigation and cost analysis; record keeping requirements under OSHA Act of 1970; safety programs and inspections; safety training; toxology, first aid and medical services; fire prevention and control methods; occupational diseases and personnel protective equipment. Prep. Admission to Graduate Program.

IIS 3406 Man-Computer Interaction (2QH)
(formerly 05.853) Spring Quarter
Design and evaluation of the man-computer interface in on-line information systems; formatting of visual displays and auditory outputs, techniques to facilitate operator inputs, pacing and control of the interactive sequence, operator training, task analysis and performance testing. Student projects in areas of novel application. Prep. IIS 3401.

IIS 3410 Advanced Human Factors Engineering (4QH)
Winter Quarter
The study of methods and techniques used to obtain and interpret human performance data. Includes examination of experimental methods and problems peculiar to experimentation with human subjects; unobtrusive measures, and non-reactive techniques; survey design and implementation; systematic observation techniques. Also covered are systems analysis and man/machine systems; function and task analysis; task allocation; support equipment and training design; error analysis; occupational safety; preconstruction; periodic and accident/critical incident analytic techniques. Prep. IIS 3509 and IIS 3400.

IIS 3503 Simulation Methodology and Applications (4QH)

Winter and Spring Quarters

Covers when, where and how to use discrete event simulation techniques. Topics include model design, development and validation; tactical and strategic planning considerations in the use of the model; input data reduction; alternative programming languages for implementing models; efficiency in running simulations, and statistical reliability in the design and analysis of simulation experiments. Several special purpose simulation languages are discussed, e.g. SIMSCRIPT, GPSS, and SIMAN. The opportunity to code models in one language is provided. Prep. IIS 3523 and higher level language.

IIS 3509 Design of Experiments (4QH)

Fall Quarter

Theory and application of experimental design techniques such as modeling and statistics which can optimize resources and improve decision making risks. This course will cover experiments with single and multiple factors of interest and consider experiments with high order experimental restrictions. Some additional analysis techniques will also be covered. Prep. IIS 3523.

IIS 3512 Stochastic Modeling and Queuing Systems (4QH)

Spring Quarter

A development of the probability techniques necessary for the study of queues, Poisson process, semi-Markov and Markov process. Analysis of the behavior of queueing systems. Single and multiple queues, queues with general arrival and general server, queues with priority. Prep. IIS 3113.

IIS 3513 Network Analysis and Advanced Linear Programming (4QH)

Concepts of network analysis and advanced linear programming are considered. Topics include spanning trees, path and flow algorithms, matchings and coverings, postman and traveling salesman problem, location problems, revised simplex and polynomial bounded algorithms, parametric programming and concepts of upper bounding and decomposition. Prep. IIS 3103.

IIS 3514 Advanced Operations Research (4QH)

(formerly 05.914) Winter Quarter

Important families of mathematical programming problems and optimization methods will be covered. Generalized networks including the transhipment, shortest route, maximal flow and the minimal spanning tree problems. The cutting plane and the branch and bound algorithm for binary and mixed integer programming problems. Introduction to nonlinear programming including unconstrained optimization, the Kuhn-Tucker conditions, gradient methods, separable, quadratic and geometric programming. Prep. IIS 3103.

IIS 3517 Statistical Decision Theory (2QH)

(formerly 05.953) Winter Quarter

Use of Bayesian statistical inference to arrive at decisions when stochastic variables are interacting; relationship to game theory; decision making over time in a sequence; important expected values and distributions; relationship of Bayesian decision theory to classical statistical inference. Prep. IIS 3506 and IIS 3523.

IIS 3518 Statistical Quality Control (4QH)

(formerly 05.954) Fall Quarter

This course is designed to study the fundamental concepts of quality planning, and improvements. Analysis and application of modern statistical process control methods, inspection error, and design of sampling plans will be given. Topics also include: software quality assurance, and study of the concepts of Deming, Ishikawa, Feigenbum, and Taguchi's approach in quality planning, organization, and improvement. Prep. IIS 3113.

IIS 3522 Systems Engineering Design and Analysis (4QH)

Spring Quarter

Principles of systems modeling and analysis using continuous simulation techniques. Topics include differential equations as system models; Laplace transformations;numerical approximation techniques; stability; steady-state error; control actions; alternative modeling schemes; and validation of system models via continuous simulation techniques. Prep. Admission to graduate school and higher level language.

IIS 3523 Applied Statistics (4QH)

Fall and Spring Quarters

This course develops statistical models for analysis and prediction of random phenomena. Topics include: review of descriptive statistics and hypothesis testing; linear models, both regression and ANOVA; chi-squared and non-parametric tests; and introduction to design of experiments. Emphasis will be placed on applying linear models in real life situations. Prep. IIS 3113.

IIS 3524 Multi-Criteria Decision Making (4QH)

Spring Quarter

Theory, computation and applications of multi-criteria decision making. Topics include techniques for generating noninferior solutions, techniques for finding the best-compromise solution, multiattribute utility functions, goal programming and multiple decision-maker methods. Prep. IIS 3103.

IIS 3525 Introduction to Reliability Analysis and Risk Assessment (4QH)

Winter Quarter

Introduction to probability theory, classical and Bayesian statistics useful for reliability analysis of large, complex systems. Bayesian probability encoding of experience data; principles of the methods of risk assessment and reliability analysis including fault trees, decision trees, and reliability block diagrams. Practical applications to industrial operations, e.g., nuclear and chemical plants, military systems, large processing plants, are treated. Prep. IIS 3113 or permission of the instructor.

IIS 3526 Advanced Reliability Analysis, Risk Assessment, and Maintenance (4QH)

Spring Quarter

Extended application and use of reliability and probabilistic risk analysis methods. Methods for common cause/dependent failure analysis, human reliability analysis, and treatment of uncertainties. Bayesian statistics applied to data analysis and discrete probability distribution (DPD) arithmetic for propagation of uncertainty. Time dependent reliability analysis, Markov models, availability, and maintenance theory. Replacement and maintenance strategy development. The role of maintenance in improving systems reliability, performance, and productivity. The Deming method of quality control. Case studies in industrial system. Prep. IIS 3525.

IIS 3535 Reliability Engineering and Testing (4QH)

This course is intended to acquaint the students with the evolving methodology of reliability as a design parameter. The problems of quantifying, assessing and verifying reliability are studied. Various factors that determine the stress and strength of components and their impact on system reliability are presented. Practical applications, examples, and problems cover a broad range of engineering fields, such as mechanical, electrical, industrial, computer, structures and automatic control systems. Prep. IIS 3113.

IIS 3540 Total Quality Control for Engineering (4QH)

Principles of Total Quality Control (TQC). Japanese management methods for technologies: manufacturing, electrical, steel, and automobile industries. Seven statistical methods of TQC: histograms, cause and effect diagrams, check sheets, Pareto diagrams, graphs, control charts, and scatter diagrams. Case studies of TQC implementation in technology management. Guest lectures by invited authorities. Prep. IIS 3113.

IIS 3601 Compiler Design (4QH)

Winter Quarter

An introduction to data structures including stacks and trees. The nature of compiling and interpreting, string manipulation and code generation. The writing of a compiler in assembly language of a BASIC-like source language will be started. The compiler design work is completed as a term project. Prep. IIS 3115, 3116, or 3117.

IIS 3604 Data Structures and Data Base Management (4QH)

Fall and Winter Quarters

Topics include arrays, stacks, lists, linked lists, queues, trees, graphs, symbol tables and files. A model of each data structure is presented and various implementations in a high level language are discussed. Algorithms for handling data are analyzed. Applications of particular structures are shown in order to emphasize the role of abstraction in problem solving with computers. Searching and sorting techniques are also covered. Prep. IIS 3106 or IIS 3115 or IIS 3117.

IIS 3607 Operating Systems and Systems Software (4QH)

Winter and Spring Quarters

A study of the concept and components of modern operating systems: (1) evolution of modern operating systems; (2) operations and services of operating systems; (3) file systems, protection and implementation; (4) scheduling of processors, multiprogramming; (5) memory management, partitions, virtual memory, overlap, allocation algorithms; (6) secondary memory management, scheduling of disks and drums; (7) operating system deadlocks, detection and prevention; (8) concurrent processes, semaphores, concurrent programming, synchronization; (9) operating system protection, access matrix; (10) design issues, multi-layered approach, virtual machines; (11) case studies in UNIX, VMS, TOPS, MULTICS. Prep. IIS 3604 and IIS 3610.

IIS 3610 Computer Architecture (4QH)

Fall and Spring Quarters

Structure and organization of modern computers: computer systems organization: digital logic circuits, integrated circuits, programmed logic arrays; memory organizations, design techniques for large scale memories; microprocessors, comparative study of Z80, MC68000; interfacing, I/O chips; design specifications of model microcomputers; microprogramming, organization of data path and microarchitecture; instruction formats; operating system concepts; assemblers, linkers, loaders; multi-level machines, program portability; special topics on super computer architecture; multiprocessors; non-von Neumann architecture. Prep. IIS 3116.

IIS 3615 Analysis and Design of Computer Information Systems (4QH)

Fall Quarter

Introduction to software engineering analysis and design techniques and computer technology. Topics covered include: techniques for determining information requirements for MIS/DSSs; development of the functional systems design; and computer system design considerations such as the CPU, main memory, operating systems functions, computer languages, input devices, secondary memory, file organization, database management systems, data communications, data security, and output and display devices. The main objective of the course is to develop capability in the skeletal design of a computer system to support a given set of information requirements. Prep. Admission to Graduate Program.

IIS 3620 Computerized Financial Control Systems (2QH)

(formerly 05.944) Spring Quarter

On-line systems for financial and inventory control from the technological, legal, and social point of view. The focus is on electronic funds transfer (EFT) and point of sale (POS) terminals and associated computing equipment for inter-bank and consumer banking transactions, debit card transactions, and retail management information systems to control cash and inventory. The current technological status and societal implications of EFT and POS terminals are discussed. Prep. IIS 3615.

IIS 3621 Information Systems and Society (2QH)
(formerly 05.948) Fall Quarter

Discussion of the role computer systems play in modern society. The beneficial use of computers in commercial and industrial enterprises is considered and contrasted with the potential for infringement of individual privacy rights. Sufficient technical material on computer hardware, software, and data communications is discussed to permit assessment of system feasibility. Relevant major legislation is related to current practice in use of computer systems. IIS 3621 and IIS 3617 cover the same material as IIS 3218, but in two 2QH courses. Prep. Admission to Graduate Program.

IIS 3622 Information Systems in a Microcomputer Environment (4QH)
Spring Quarter

The contribution of microcomputers and local area networks to the implementation of comprehensive decision support systems. The IBM PC, or compatible machine, is used as a representative microcomputer. Detailed examination of the aspects of microcomputer architecture essential to the understanding of this contribution is provided. Topics include: PC architecture, PC operating system, the use of interrupts, data communications and local area network design issues, and approaches to the rational design and selection of software for PCs. Assignments using the PCs are used to develop insight into the operation of the PC at its lowest level and to experience and evaluate generic categories of PC software. Prep. IIS 3615.

IIS 3623 File Processing (2QH)
(formerly 05.938) Winter Quarter

Processing of sequential, indexed-sequential, and direct/relative data files on tape and disk; record blocking, searching, sorting, and merging operations; random access techniques; introduction to data base management concepts, and if time permits an introduction to RPG. Prep. IIS 3111 or knowledge of COBOL Programming.

IIS 3624 Software Engineering I (4QH)
Winter Quarter

An introductory course on software design techniques. Software requirements and specifications. System architecture design methodology: classifications, top-down, bottom-up, HIPO, Warnier-Orr and Jackson design methodologies. Data flow charts; module strength and independence; software reliability and maintainability in the design stage. Elements of programming methodology: style, tools, environments, documentation. Software project management. Analysis of programming languages in the light of software engineering principles. Prep. IIS 3604.

IIS 3625 Software Engineering II (4QH)
Spring Quarter

Advanced topics in software engineering: software complexity measures; memory requirements and processing time analysis; program testing and debugging methods; proving programs correct; implementation issues; elements of reliability theory and applications to software engineering. Management of software design projects; an examination of software efficiency principles through case studies of large software projects. Application and comparison of various software development tools. Prep. IIS 3607, 3624.

IIS 3626 Networks and Telecommunications (4QH)
Winter and Spring Quarters

Network goals and applications; architecture, topologies, and protocols; layered communications protocol design; layer functions, interlayer interfaces, and peer processes; performance measures; data communication techniques; wide area and local networks; channel interfaces and access schemes; workstations and server nodes; distributed systems; internetworking. Prep. IIS 3610.

IIS 3627 Software Economics (4QH)

Winter Quarter

An examination of the constructive cost model (COCOMO model) is presented in the context of the software life cycle. Case studies will be analyzed. Economic analysis tools are presented relative to software development and/or selection; marginal analysis, present value, future worth and systems analysis techniques. Methods for dealing with uncertainty and performing risk analyses. A seven step program for estimating software cost; COCOMO cost drivers, evaluation procedures and software project planning and control. Prep. IIS 3624.

IIS 3628 Data Base Management Systems (4QH)

Fall, Winter and Spring Quarters

Fundamental concepts and design of data base management systems (DBMS). Topics include the role of DBMS in organizations; alternative data base models - hierarchical, network and relational; underlying data structures for each data base model; example DBMS for each model type; design of an information system using a DBMS approach; practical experience with at least one DBMS on a microcomputer or minicomputer, such as RBase 5000 or Data-Trieve. Prep. IIS 3604.

IIS 3629 Expert Systems in Engineering (4QH)

This course is designed to introduce students to the theory, topics and applications of expert systems in engineering. Topics include knowledge representation formats (production rules, frames, networks, logic systems), heuristics in engineering (deterministic and nondeterministic), fuzzy logic, certainty factors, cognition, memory, decision strategies, design of expert systems, shells, current research goals and applications in engineering. Each development and/or application. Prep. Admission to graduate program.

IIS 3630 Introduction to Machine Intelligence (4QH)

This course deals with the area of intelligent computer systems, i.e., such that exhibit some behavior normally attributed to humans - solving problems, reasoning, learning, handling collections of expert knowledge. This course focuses on methods, techniques and implementations of computer systems for problem solving in the area of engineering. The course uses logic and predicate calculus as a starting base, all other representations are explained in terms of the predicate calculus representation. Prep. A strong background in structured programming methods (IIS 3106 or equivalent) and data structures (IIS 3604 or equivalent) is required. Lisp or Prolog is desirable but not necessary.

IIS 3631 Machine Learning (4QH)

This course introduces the students to the problem of developing programs that can learn (i.e., increment their knowledge in the process of execution). It covers some basic principles, techniques, tools and algorithms for building learning systems. The course concentrates on the methods of implementation of the learning algorithms in software rather than on the human learning mechanisms. Classification of machine learning methodology, algorithms and programs is discussed. Current research being conducted in the field of machine learning at various institutions throughout the world is presented. Prep. A high level programming language (Lisp or Prolog preferable), and an introductory course to machine intelligence (IIS 3630 - Introduction to Machine Intelligence, or equivalent).

IIS 3651 Software Engineering Project (8QH)

Spring Quarter

Team work under faculty supervision on a large software project. The projects are drawn from an engineering field, design, systems engineering, manufacturing, planning maintenance, reliability, quality control, risk assessment, project control, evaluation of alternatives, etc. The project may cover either the whole software development life cycle or a significant part of it. Prep. IIS 3624, permission of instructor.

IIS 3652 Software Engineering Project I (4QH)

Spring Quarter

IIS 3652 and IIS 3653 cover the same material as IIS 3651, but in two four-quarter-hour courses.

IIS 3653 Software Engineering Project II (4QH)

Spring Quarter

IIS 3652 and IIS 3653 cover the same material as IIS 3651, but in two four-quarter-hour courses.

IIS 3797 Engineer Degree Continuation (0QH)

Any Quarter

IIS 3798 Master's Continuation (0QH)
(formerly 05.9X1) Any Quarter

IIS 3799 PhD Continuation (0QH)
(formerly 05.9X5) Any Quarter

IIS 3801 Special Project in Industrial Engineering (2QH)
(formerly 05.993) Any Quarter
Individual work under faculty supervision. Prep. Consent of advisor.

IIS 3802 Special Project in Industrial Engineering (4QH) Any Quarter

Same as IIS 3801.

IIS 3803 Independent Study in Operations Research (2QH)
(formerly 05.919) Any Quarter
Special topics in Operations Research by arrangement with a faculty member

IIS 3804 Special Topics (4QH)

Any Quarter

Special Topics in IE and IS. Prep. Permission of Instructor.

IIS 3805 Special Topics (2QH)

Any Quarter

Special Topics in IE and IS. Prep. Permission of Instructor.

IIS 3806 Seminar in Industrial Engineering (2QH)
(formerly 05.992) Any Quarter
Discussion and presentations of thesis related topics by students , presentations and discussions by faculty and eminent people in the field on timely industrial engineering topics. Field trips and visitations included where appropriate. Prep. Permission of instructor.

IIS 3863 Thesis (Master's Degree) (2QH) Any Quarter

Analytical and/or experimental work conducted under the auspices of the Department. Prep. Consent of advisor.

IIS 3864 Thesis (Master's Degree) (4QH)

Any Quarter

Same as IIS 3863.

IIS 3865 Thesis (Master's Degree) (8QH)

Any Quarter

Same as IIS 3863.

IIS 3870 Industrial Engineer Degree Project (10QH)
(formerly 05.994) Any Quarter
Undertaken with the approval of the candidate's advisor and the Department Graduate Committee.

IIS 3873 Industrial Engineer Degree Project (4QH)
Any Quarter
Same as IIS 3870.

IIS 3874 Industrial Engineer Degree Project (2QH)
Any Quarter
Same as IIS 3870.

IIS 3881 Doctoral Thesis (8QH)
Any Quarter
Doctoral Thesis research conducted under advisorship of the doctoral student's dissertation committee. Prep. Admission to doctoral candidacy.

IIS 3883 Doctoral Thesis (4QH)
Any Quarter
Same as IIS 3881.

IIS 3884 Doctoral Thesis (2QH)
Any Quarter
Same as IIS 3881.

DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering offers the degrees of Master of Science in Mechanical Engineering, Mechanical Engineer, and Doctor of Philosophy. The Master of Science degree may be pursued on either a full-time or a part-time basis. A full-time student may apply for participation in the Cooperative Plan. The Mechanical Engineer and Doctor of Philosophy degrees are pursued on a basis consistent with the residence requirements for the degree. The curriculum offers areas of concentration in Mechanics, Thermofluids Engineering, and Materials Science and Engineering.

Master of Science Degree Requirements

Students who have been accepted to the program and have received the degree of Bachelor of Science in Mechanical Engineering, or a closely-allied engineering field from a recognized college or university, will qualify for the Master of Science in Mechanical Engineering degree upon successful completion of program requirements. Students with a Bachelor of Science degree in other engineering or related science fields will qualify for the degree of Master of Science without specification.

A minimum of forty quarter hours of graduate study is required for the Master of Science degree. Full-time students, both continuous and cooperative, are required to complete a seminar program and a thesis for eight quarter hours of credit. The thesis and seminar course is not required of part-time students. All students must consult with their advisor or the Department's assigned Graduate Officer for course sequencing and the selection of elective courses in each area of concentration. Approval of course selections by the advisor or the Department's assigned Graduate Officer is required.

Mechanics

Course Requirements	Full-time Study	Part-time Study
Required Core Courses	16 QH	16 QH
Required Electives	10 QH	14 QH
Thesis	8 QH	0 QH
Other Courses	6 QH	10 QH
Minimum Quarter Hours Required *	40 QH	40 QH

*exclusive of any preparatory courses

Required Core Courses (2 QH equivalents are in parentheses)	Credits
ME 3100 (3101,3102) Math. Methods for Mechanical Engineers	4
ME 3120 (3121,3122) Theory of Elasticity	4
ME 3140 (3141,3142) Advanced Dynamics	4
ME xxxx Required Core Course from Thermofluids Engineering or Materials Science and Engineering	4
Required Electives	
ME 3400 - ME 3539 Adv. Electives in Mechanics or Design	10 or 14
Thesis - ME 3860, ME 3861, ME 3862	8
Other Courses	
Advanced Courses in Engineering or Science with No More Than Six (6) Quarter Hours Outside the Department	6 or 10

Thermofluids Engineering

Course Requirements	Full-time Study	Part-time Study
Required Core Courses	16 QH	16 QH
Required Electives	8 QH	8 QH
Thesis	8 QH	0 QH
Advanced ME Electives	0 QH	8 QH
Other Courses	8 QH	8 QH
Minimum Quarter Hours Required*	40 QH	40 QH

*exclusive of any preparatory courses

Required Core Courses(2 QH equivalents are in parentheses) Credits

- ME 3100 (3101,3102) Math. Methods for Mechanical Engineers.....4
- ME 3200 (3201,3202) General Thermodynamics.....4
- ME 3210 (3211,3212) Essentials of Fluid Dynamics.....4
- ME xxxx Required Core Course from Mechanics or Materials Science and Engineering.....4

Required Electives Selection

- ME 3540 (3541,3542) Heat Conduction and Thermal Radiation.....4
- ME 3544 (3545,3546) Convective Heat Transfer.....4
- ME 3560 (3561,3562) Viscous Flow.....4
- ME 3564 (3565,3566) Gas Dynamics.....4
- ME 3580 (3581,3582) Statistical Thermodynamics.....4
- ME 3584 (3585,3586) Fundamentals of Combustion.....4

Thesis - ME 3860, ME 3861, ME 3862.....8

Advanced ME Electives (ME 3400 - ME 3699).....0 or 8

Other Courses

- Advanced Courses in Engineering or Science with No More Than Six (6) Quarter Hours Outside the Department.....8

Materials Science and Engineering

Course Requirements	Mechanical Behavior of Materials		Materials Science & Engineering	
	Full-time	Part-time	Full-time	Part-time
Required Core Courses	16 QH	16 QH	16 QH	16 QH
Required Electives	4 QH	4 QH	0 QH	0 QH
Thesis	8 QH	0 QH	8 QH	0 QH
Other Courses				
Advanced Material Science and Engineering Electives	12 QH	0 QH	0 QH	0 QH
Advanced Courses in Engineering or Science	0 QH	20 QH	16 QH	24 QH
Minimum Quarter Hours Required*	40 QH	40 QH	40 QH	40 QH

*exclusive of any preparatory courses

Required Core Courses(2 QH equivalents are in parentheses) Credits

- ME 3250,3251 Advanced Physical Metallurgy I & II.....2 each
- ME 3260,3261 Thermodynamics of Materials I & II.....2 each
- ME 3272 (3270,3271) Material Science & Engineering I & II.....4
- ME xxxx Required Core Course from Mechanics or Thermofluids Engineering.....4

Required Elective

- ME 3100 (3101,3102) Math Methods of Mechanical Engineers.....4

Thesis - ME 3860, ME 3861, ME 3862.....8

Other Courses

- Advanced Material Science Electives and Engineering Electives (ME 3600 - ME 3659); Up to six (6) quarter hours can be taken outside the department.....12
- Advanced courses in Engineering or Science with No More Than Six (6) Quarters Outside the Department.....20,16, or 24

The Mechanical Engineer Degree

The Mechanical Engineer degree program is offered for those who wish to undertake graduate study beyond the Master of Science degree without committing themselves to a program as extensive as that required for the Doctor of Philosophy degree. The program permits a candidate to pursue a course of study at the upper graduate level in more than one area of Mechanical Engineering as distinguished from the specialization usually associated with the doctoral program.

Qualification, Degree Candidacy and Examinations

A student admitted to the Mechanical Engineer degree program will be designated a Candidate for this degree. The Candidate's advisor normally will be the faculty member who will supervise the thesis. A student must maintain a 3.00 grade point average to qualify for the degree. Students admitted on a conditional basis may be required to pass special examinations. The Graduate Committee will determine the need for and will administer any such special examinations. A final oral examination consisting of a defense of the thesis may be required if the Candidate's advisor decides.

Program Requirements

A minimum of 40 quarter hours of credit beyond the Master of Science degree is required. Up to 10 quarter hours of credit will be permitted for work on a thesis. A student would have chosen two areas of concentration prior to acceptance to furnish the broad background which characterizes the degree of Mechanical Engineer.

Any transfer of credits must be approved by the Mechanical Engineering Graduate Committee. After admission to the program, a maximum of five years will be permitted for completion of the degree. Following approval of the Candidate's program, registration must be continuous. Withdrawal or changes in the program must be approved by the Graduate Committee.

Language Requirement

There is no language requirement for the Mechanical Engineer degree.

Residence Requirement

The residence requirement is satisfied by two academic quarters of full-time graduate work during the academic year or by four academic quarters of half-time graduate work during two consecutive academic years. Plans for satisfying the residence requirement on a half-time basis must be approved by the Graduate Committee.

Thesis

To be awarded the Mechanical Engineer degree, each candidate must complete a thesis demonstrating a high level of competence in research, development, or design in the field of Mechanical Engineering. The effort normally expected will be the equivalent of 10 quarter hours of graduate course work.

The Doctor of Philosophy Degree

The degree of Doctor of Philosophy is awarded to those candidates who demonstrate high attainment and research ability in the field of Mechanical Engineering. Upon acceptance into the program, a student is designated a Doctoral Student.

Qualifying Examination

The qualifying examination in the Department of Mechanical Engineering is offered yearly, usually during the Winter Quarter, and is both written and oral. At the present time, the written portion of the qualifying examination is six hours in length and covers, with equal emphasis, four different areas. A student must select one area from each of the three groups A, B, and C, plus another area either listed below or unlisted, but considered equivalent and approved by the Graduate Committee. A student who is classified as interdisciplinary, may request modifications in testing areas. Requests must be approved by the Graduate Committee.

A. Concepts of Thermodynamics; Applied Thermodynamics

B. Dynamics; Mechanics of Deformable Bodies

C. Heat and Mass Transfer; Fluid Mechanics; Mechanical Behavior of Materials; Physical Metallurgy

The Department of Mechanical Engineering reserves the right to modify the details of the qualifying examination. Approval of the college and reasonable notification to candidates is inferred relative to modifications.

The oral portion of the qualifying examination is conducted by a committee consisting of at least four members appointed by the Graduate Committee. A typical committee is composed of two members specializing in the student's major area plus one member from each of two other areas.

The qualifying examination may be taken by a graduate student who expects to complete the requirements for his Master of Science degree within three months of the date of the qualifying examination as well as by a person who has already completed the requirements for the Master of Science degree. Because degree candidacy must be established before the Graduate Committee will act to approve course programs or dissertation proposals, the qualifying examination should be taken at the earliest opportunity. If the examination is failed, it may be repeated with permission of the departmental Graduate Committee.

All Doctoral Students must take the qualifying examination within 18 months of acceptance.

After 40 quarter hours of graduate work have been taken with satisfactory grades and upon successful completion of the qualifying examination, a student is designated a Doctoral Candidate.

Course Requirements

To receive the PhD degree a candidate must complete a program of course work approved by the Graduate Committee. Courses completed prior to admittance to the doctoral program are subject to the approval of the Graduate Committee. Each program must contain at least twelve quarter hours of course work, preferably outside of the department, in an area other than that in which the candidate is concentrating. Attainment of a 3.00 grade point average for the courses in the "minor" portion of the program will signify satisfactory completion of that portion.

Language Requirement

A reading knowledge of one foreign language is required. Proficiency in a language shall be determined in a manner prescribed by the departmental Graduate Committee. The language requirement must be fulfilled within six months after the dissertation proposal has been accepted but no less than six months before the degree is granted.

Residence Requirement

The residence requirement is satisfied by one year of full-time graduate work or by two years of half-time graduate work beyond the Master of Science degree. However, a student should expect to spend at least two years, or the equivalent, in full-time graduate study beyond the requirements of the Master of Science degree.

Dissertation

After degree candidacy has been established, a candidate must complete a dissertation which embodies the results of extended research and includes materials suitable for publication.

The departmental Graduate Committee may require the completion of certain course work before permitting dissertation work to commence. A Dissertation Committee will be appointed by the departmental Graduate Committee. The Dissertation Committee will be kept informed of the work and will be responsible for initial approval of the dissertation in its final form.

Comprehensive Examination

The comprehensive examination is combined with the final oral examination and is given after the dissertation has been completed and approved. This examination is based upon the subject matter of the dissertation and a defense of it.

Final Oral Examination

The final oral examination is taken after completion of all other requirements for the degree. This examination cannot be held until two weeks have elapsed after the dissertation has been registered and accepted by the Graduate School and must be passed at least two weeks before the commencement at which the degree is to be awarded.

The final oral examination will include the subject matter of the doctoral dissertation and significant developments in the field of the dissertation work. Other fields may be included if recommended by the examining committee.

Faculty

Charles A. Berg, Chairman
Alvin J. Yorra, Associate Chairman

Professors

Adams, George G., PhD, University of California at Berkley; response of elastic structures to moving loads; tribology stress distributions at material interfaces; elasticity; stability

Berg, Charles A., ScD, MIT; mechanical properties of materials; fracture, fatigue and wear; theoretical mechanics; engineering properties of materials; energy conservation and advanced technology; history of technology; engineering aspects of economics

Cipolla, John W., Jr., PhD, Brown University; laser-aerosol interactions including thermophoresis; heat and mass transfer; radiative transfer; kinetic theory

Dunn, John F., Jr., ScD, MIT; system dynamics, vibration, feedback control, electrohydraulic servosystems, servovalves

Foster, Arthur R., MEng, Yale University; solar thermal heating and cooling, nuclear fuel cycle analysis; functional analysis of nuclear and fossil power cycles

Gorlov, Alexander M., PhD, Moscow Institute of Transport Engineers; mechanical and structural design; low-head hydropower systems conversion; theoretical and applied mechanics

Murphy, Richard J., PhD, MIT; production and consolidation of amorphous metal powder

Nowak, Welville B., Donald W. Smith Professor of Mechnical Engineering, PhD, MIT; materials science and engineering; thin films for resistance to corrosion, diffusion and wear; photovoltaic solar cells; electronic materials

Rossettos, John N., PhD, Harvard University; buckling and vibration of stiffened plates, mechanics of composite materials, applied mechanics

Zotos, John, MetEng, MIT; mathematical modeling of the chemical, mechanical, and physical properties of engineering alloys; materials science and engineering; thermodynamics of materials; joining similar and dissimilar metals and alloys

Associate Professors

Blanchard, Ralph S.,MS, Northeastern University; vibration analysis; mechanical design; product liability

Blucher, Joseph T., PhD, MIT; surface treating processes CVD, PVD, ion nitriding, and laser processing; metal matrix composites; powder metallurgy; welding; cutting tools; manufacturing processes; failure analysis; fracture; fatigue; wear

Hashemi, Hamid N., PhD, MIT; materials; composite materials; non-destructive evaluation; mechanics; finite-elements; fatigue; wear; reliability-centered maintenance

Kowalski, Gregory J., PhD, University of Wisconsin-Madison; radiation and combined-mode heat transfer; heat and mass transfer; fluid dynamics

Long, Bertram, ME, MIT; biomechanical systems; structural elasticity

Metghalchi, Mohamad, ScD, MIT; internal combustion engines; energy conversion; air pollution; laminar and turbulent flame speeds; chemical kinetics

Narusawa, Uichiro, PhD, University of Michigan; natural and double-diffusive convection in enclosures and saturated porous media; two-phase flows; thermocapillary flow

Taslim, Mohammad E., PhD, University of Arizona; computational and experimental fluid mechanics and heat transfer; double diffusive convection

Yener, Yaman, PhD, North Carolina State University; heat and mass transfer, radiative t+ransfer, radiation-aerosol interaction including thermophoresis

Yorra, Alvin J., MS, MIT; motion of spinal components relating to disc wear; forensic design; rocket dynamics

Zeid, Ibrahim, PhD, University of Akron; CAD/CAM, finite-element method, applied mechanics

Assistant Professors

Wang, Wego, ScD, MIT; mechanical properties of materials; microstructural analysis; rapid solidification process; computer simulation

Advisors

	Full-time	Part-time
Thermofluids Engineering	(A-Z) Prof. Yener	(A-Z) Prof. Sullivan
Materials Science & Engg	(A-Z) Prof. Nowak	(A-Z) Prof. Nowak
Mechanics	(A-Z) Prof. Adams	(A-Z) Prof. Adams

Each course description includes information on the expected quarter in which classes are usually offered. The quarters listed are presented here for planning purposes; however, the Graduate School of Engineering cannot guarantee that all courses will be offered. Students must refer to the Graduate School of Engineering Quarterly Course Offering sheets to determine what courses are actually offered in any given quarter and at what day and time. `Odd' and `Even' years refer to the fall quarter of the academic year, i.e., Spring 89 which is in the 88-89 academic year, would be an `Even' year.

ME 3100 Mathematical Methods for Mechanical Engineers (4QH)
(formerly 02.825) Fall Quarter
Embodies the material in ME 3101 and ME 3102. Prep. Admission to the Graduate School of Engineering.

ME 3101 Mathematical Methods for Mechanical Engineers I (2QH)
(formerly 02.826) As Announced
Bessel and Legendre functions, boundary-value problems and series of orthogonal functions. Partial differential equations and applications to heat transfer, fluid flow, vibrations and wave propagation. Prep. Admission to the Graduate School of Engineering.

ME 3102 Mathematical Methods for Mechanical Engineers II (2QH)
(formerly 02.827) As Announced
Vector analysis; divergence theorem; functions of a complex variable; Laurent series and singular points; residues and contour integration; applications. Prep. Admission to the Graduate School of Engineering.

ME 3120 Theory of Elasticity (4QH)
(formerly 02.807) Fall, Winter Quarters
Embodies the material in ME 3121 and ME 3122. Prep. Admission to the Graduate School of Engineering.

ME 3121 Theory of Elasticity I (2QH)
(formerly 02.804) As Announced
Analysis of Cartesian tensors using indicial notation. Stress and strain concepts; point stress and strain; relation to tensor concepts. Governing equations for the determination of stress and displacement distributions in a solid body. Exact solutions of the governing equations for elastic solids. Prep. Admission to the Graduate School of Engineering.

ME 3122 Theory of Elasticity II (2QH)
(formerly 02.805) As Announced
Plane stress and strain problems in rectangular and polar coordinates including thermal stress. Relation of elasticity theory to strength of materials. Torsion of prismatic and axially symmetric bars. Bending of thin flat rectangular and circular plates. Prep. ME 3121.

ME 3140 Advanced Dynamics (4QH)
Winter, Spring Quarters
Embodies the material in ME 3141 and ME 3142. Prep. Admission to the Graduate School of Engineering.

ME 3141 Advanced Dynamics I (2QH)
(formerly 02.847) As Announced
Kinematics of particles and rigid bodies. Modeling and application of fundamental laws of motion. Dynamic response of lumped parameter systems. Prep. Admission to the Graduate School of Engineering.

ME 3142 Advanced Dynamics II (2QH)
(formerly 02.848) As Announced
Continuation of ME 3141. Lagrange's equations. Applications in two and three dimensions. Prep. ME 3141.

ME 3200 General Thermodynamics (4QH)
(formerly 02.903) Winter, Spring Quarters, Odd Years
Fundamentals of equilibrium thermodynamics will be examined. Topics include: work, energy, heat, temperature, available energy, entropy, first and second law of thermodynamics, simple systems, closed and open systems, availability loss and irreversibility, heat engines, multicomponent systems, mixtures of gases, chemical reactions and chemical equilibrium. Equivalent to courses ME 3201 and ME 3202. Prep. Admission to the Graduate School of Engineering.

ME 3201 General Thermodynamics I (2QH)
(formerly 02.901) As Announced
ME 3201 and ME 3202 present the same material contained in ME 3200, but in two 2QH courses. Prep. Admission to the Graduate School of Engineering.

ME 3202 General Thermodynamics II (2QH)
(formerly 02.902) As Announced
Continuation of ME 3201. Prep. ME 3201.

ME 3210 Essentials of Fluid Dynamics (4QH)
(formerly 02.821) Fall, Winter Quarters, Even Years
A fundamental course in fluid dynamics designed to prepare the student for more advanced courses in the thermofluids curriculum while providing a strong background in fluid mechanics. Topics to be covered may include: Cartesian tensors; Differential and integral formulation of the equations of conservation of mass, momentum and energy; molecular and continuum transport phenomena; The Navier-Stokes equations; Vorticity; inviscid, incompressible flow, the velocity potential and Bernoulli's equation; Viscous incompressible flow; the stream function; some exact solutions; energy equation including heat conduction and viscous dissipation. This material is also covered in the two 2QH courses ME 3211 and ME 3212. Prep. Admission to the Graduate School of Engineering.

ME 3211 Essentials of Fluid Dynamics I (2QH)
(formerly 02.819) As Announced
ME 3211 and ME 3212 present the same material with the same prerequisites as ME 3210, but in two 2QH courses. Prep. Admission to the Graduate School of Engineering.

ME 3212 Essentials of Fluid Dynamics II (2QH)
(formerly 02.820) As Announced
Continuation ME 3211. Prep. ME 3211.

ME 3250 Advanced Physical Metallurgy I (2QH)
(formerly 02.953) Fall Quarter, Odd Years
Dislocation theory; including such topics as dislocation stress fields, self-energy, velocity, interactions mechanisms, image forces, and theories of yielding. Prep. A recent introductory material science course.

ME 3251 Advanced Physical Metallurgy II (2QH)
(formerly 02.954) Winter Quarter, Odd Years
Mechanical behavior of metals. Application of dislocation theory to micro-plasticity, strain hardening, strengthening mechanisms and creep. Prep. ME 3250.

ME 3260 Thermodynamics of Materials I (2QH)
(formerly 02.960) Fall Quarter, Odd Years
Basic metallurgical thermodynamics encompassing first, second, and third laws, entropy, enthalpy, and free energy. Prep. Engineering materials.

ME 3261 Thermodynamics of Materials II (2QH)
(formerly 02.961) Winter Quarter, Odd Years
Continuation of ME 3260 with emphasis on solutions, activity, activity coefficients, the phase rule and applications to some metallurgical problems. Prep. ME 3260.

ME 3270 Materials Science and Engineering I (2QH)
(formerly 02.970) As Announced
Principles underlying the structure and properties of solid materials. The relationships of these principles to the properties and to applications in structures and devices. Both macroscopic-phenomenological and electronic-molecular approaches will be used. Materials will include metals and alloys, semiconductors, and dielectrics. Typical subjects are atomic and electronic structures, ordering, nucleation, crystal growth, and thermal properties. Prep. A recent introductory material science course.

ME 3271 Materials Science and Engineering II (2QH)
(formerly 02.971) As Announced
Continuation of ME 3270 into additional topics such as electric, magnetic, and optical properties; applications of solid-state phenomena to achieve functions embodied in transducers, filters, amplifiers, energy converters, and so forth. Prep. ME 3270.

ME 3272 Materials Science and Engineering (4QH)
Fall Quarter
Embodies the material in ME 3270 & 3271. Prep. A recent introductory materials science course.

ME 3341 Power Generating Systems I (2QH)
(formerly 02.935) As Announced
Power generating systems that employ fossil, nuclear, and heat recovery boilers operating in conjunction with steam and organic Rankine cycles are examined. The steady-state and transient operation of each power generating system is studied from both an analytical and conceptual point of view. The effect that site conditions, fuel quality, plant loading schedule and environmental regulations have on system design, performance and operation is presented. Prep. ME 3200 or equivalent, or may be taken concurrently with permission of instructor.

ME 3342 Power Generating Systems II (2QH)
(formerly 02.936) As Announced
An extension of ME 3341. The same type of examination is conducted of systems incorporating gas, hydraulic, and wind turbines, solar and fuel cells, energy storage, combined cycles, and cogenerating systems. The objective of Power Generating Systems I and II is to develop the skills needed to conduct sound technical evaluations of the power generating systems being built today. Prep. ME 3341.

ME 3343 Power Generation Economics and Planning (2QH)
(formerly 02.938) As Announced
Current and constant-dollar power generation costs are examined. Life cycle economic analysis, such as revenue requirements, discounted cash flow, internal rate of return, and payback analyses, are presented. The planning methodologies used by electric utilities and private industry to evaluate and select power generating systems are presented. Prep. ME 3342.

ME 3351 Solar Thermal Engineering I (2QH)
(formerly 02.855) As Announced
A model is developed for the hourly direct and diffuse radiation under a cover of scattered clouds and the transmission and absorption of this radiation by passive and active systems. The design of air heating systems and the storage of the collected energy by a pebble-bed are considered, as well as elements of heat exchanger design. A study of the economics of a domestic water and/or space heating system is made using f-chart analysis. Prep. CHE 3659, Solar Energy Thermal Processes or equivalent background.

ME 3352 Solar Thermal Engineering II (2QH)
(formerly 02.856) As Announced
The design and analysis of several solar thermal systems are considered, such as: LiBr-H2O absorption cooling units, heat pumps, compound parabolic collectors, and the heat pipe type of solar collector. Prep. ME 3351.

ME 3360 Turbomachinery Design (4QH)
Fall Quarter
Preliminary design methods and analytical tools applicable to turbomachinery are presented. Design criteria and performance characteristics at design and off-design operating conditions are discussed for several important types of turbomachinery. Axial flow compressors and turbines (gas and steam) are studied in some depth, including topics such as compressor surge, turbine blade cooling, and steam wetness effects. Centrifugal compressors, radial inflow turbine, pumps, fans, and water turbines are also studied. Turbomachinery mechanical design limitations are discussed. The use of empirical data on blade cascade performance in blade selection is examined. Numerical methods of analyzing two- and three-dimensional flows in turbomachinery (e.g., conformal transformation and streamline curvature) are presented. Two in-depth design projects are assigned. This material is also covered in the two 2QH courses ME 3361 and ME 3362. Prep. Admission to the Graduate School of Engineering, including undergraduate preparation in fluid mechanics and thermodynamics.

ME 3361 Turbomachinery Design I (2QH)
(formerly 02.930) As Announced
ME 3361 and ME 3362 present the same material contained in ME 3360, but in two 2QH courses. Prep. Admission to the Graduate School of Engineering, including undergraduate preparation in fluid mechanics and thermodynamics.

ME 3362 Turbomachinery Design II (2QH)
(formerly 02.931) As Announced
Continuation of ME 3361. Prep. ME 3361.

ME 3370 Fundamentals of Maintenance in Design (4QH)
(new course) Spring Quarter, Odd Years
Basic tools of probability analysis will be covered. Failure modes and actual functional behavior of designed components will be presented in the probability forms. Age reliability will be discussed. Nondestructive evaluation techniques will be presented and demonstration tests will be performed. Fault tree analysis and decision logic will be covered. Prep: Admission to the Graduate School of Engineering.

ME 3380 Fundamentals of Instrumentation (2QH)
(formerly 02.853) Fall Quarter
Theoretical principles underlying the design and operation of instruments for measurement and/or control. Analysis of stimulus-response relations. Industrial instruments for measurement and control, including those based on pneumatic and electrical systems. Prep. Bachelor of Science degree.

ME 3381 Industrial Process Control (2QH)
(formerly 02.854) Winter Quarter
Fundamental principles involved in automatic control of industrial processes. Economic considerations. Application of control instruments to obtain automatic control of temperature, pressure, fluid flow, liquid level, humidity, PH. Prep. ME 3380.

ME 3386 Nuclear Engineering I (2QH)
(formerly 02.942) As Announced
Topics include: growth of nuclear power industry; study of nuclear physics emphasizing atomic and nuclear structure, radioactive decay, and nuclear reactions with particular attention to fission and fusion; radiation health physics; principles of shielding; nuclear instrumentation; production and application of radioisotopes; neutron interactions and slowing down theory; neutron activation analysis. (Not open to students who have completed ME 1541 and ME 1542). Prep. Admission to the Graduate School of Engineering.

ME 3387 Nuclear Engineering II (2QH)
(formerly 02.943) As Announced
Comparison of thermal, fast, and breeder reactors; four factor formula and the neutron diffusion equation; one-group, modified one-group, two-group and multi-group theory; bare and reflected thermal reactors; energy production and distribution within core; flux shaping; transient reactor behavior and control; factors affecting reactivity including temperature, pressure, void formation, fission product accumulation, fuel depletion and fuel breeding; Xenon buildup after shutdown. (Not open to students who have completed ME 1541 and ME 1542). Prep. ME 3386.

ME 3388 Nuclear Engineering III (2QH)
(formerly 02.944) As Announced
Reactor design considerations; interrelationship of reactor physics, control, engineering, materials, safety, and fuel cycle management; reactor types; radiation damage and reactor materials; nuclear fuels; reactor heat transfer; economics of nuclear power; environmental effects. (Not open to students who have completed ME 1541 and ME 1542). Prep. ME 3387.

ME 3400 Advanced Math Methods for Mechanical Engineers (4QH)
As Announced
Embodies the material in ME 3401 & 3402. Prep. ME 3100.

ME 3401 Advanced Math Methods for Mechanical Engineers I (2QH)
(formerly 02.828) As Announced
Matrices and linear equations. Variational calculus and applications. Approximate methods of engineering analysis. Selected topics of current interest. Prep. ME 3101 and ME 3102.

ME 3402 Advanced Math Methods for Mechanical Engineers II (2QH)
As Announced
Integral transforms; asymptotic expansion; regular and singular perturbation methods. Examples drawn from solid mechanics, vibration, and fluid mechanics. Prep. ME 3101 & ME 3102.

ME 3410 Numerical Methods in Mechanical Engineering (4QH)
Winter Quarter
Numerical methods applied to problems in mechanical engineering. Solution of linear and non-linear systems of equations, interpolation, numerical differentiation and integration, numerical solution of ordinary differential equations: explicit and implicit methods, multi-step methods, predictor-corrector methods. Numerical solution of partial differential equations with emphasis on parabolic and elliptic problems occurring in mechanical engineering. This material is also covered in the two 2QH courses ME 3411 and ME 3412. Prep. ME 3100.

ME 3411 Numerical Methods in Mechanical Engineering I (2QH)
As Announced
ME 3411 and ME 3412 present the same material with the same prerequisites as ME 3410, but in two 2QH courses.

ME 3412 Numerical Methods in Mechanical Engineering II (2QH)
As Announced
Continuation of ME 3411. Prep. ME 3411.

ME 3420 Mechanics of Inelastic Solids (4QH)
Spring Quarter, Odd Years
Constitutive relations governing inelastic solids. Yield surface; plastic stress-strain relations; Prandtl-Reuss equations. Viscoelastic stress-strain relations including the Maxwell and Voigt models. Viscoplasticity. Prep. ME 3122. Not available to students who have taken ME 3421.

ME 3421 Introduction to Plasticity (2QH)
(formerly 02.809) Winter Quarter, Even Years
Basic experimental information. Review of stress and strain tensors. Elastic stress-strain relations. Yield surface. Plastic stress-strain relations. Prandtl-Reuss equations. Simple applications. Prep. ME 3121.

ME 3423 Theory of Elasticity III (2QH)
(formerly 02.806) Spring Quarter
Approximate solutions for stress and displacement distributions in elastic solids; discrete solutions using finite difference and finite element methods; energy principles and the calculus of variations; use of energy principles to obtain approximate continuous solutions. Prep. ME 3122, Theory of Elasticity II.

ME 3431 Engineering Fracture Mechanics (4QH)
Fall Quarter, Odd Years
Embodies the material in ME 3432 & 3433. Prep. ME 3120.

ME 3432 Engineering Fracture Mechanics I (2QH)
(formerly 02.838) As Announced
Fundamentals of brittle fracture; theoretical strength, micro/macro fracture characteristic, Inglis-Griffith theory, applicability of same. Linear elastic fracture mechanics; Orewan/Irwin extension to metals, effective surface tension and relation to fracture toughness, plastic zone size correction; geometry effects on fracture toughness; plane strain/plane stress fracture toughness, thickness effects. Prep. ME 3122.

ME 3433 Engineering Fracture Mechanics II (2QH)
(formerly 02.839) As Announced
Experimental determination of fracture toughness; slow crack growth "pop in", arrest, R-G curves, compliance techniques for determining elastic energy release note. Alternate fracture toughness concepts; resistance curve, crack opening displacement, the J integral. Application of fracture mechanics to fatigue. Design methods to minimize risks of catastrophic failure will be emphasized. Prep. ME 3432.

ME 3434 Engineering Fracture Mechanics III (2QH)
(formerly 02.829) As Announced
Application of fracture mechanics to fatigue, strain energy density criteria for fracture, arrest criteria. "Work of Fracture" specimen. Application of fracture mechanics to structural analysis. Effect of anisotropy in fracture mechanics. Fracture dynamics, dynamic fracture toughness, strain rate effects. Micro-second fracture phenomenon and criteria, spall, Butcher-Tuler criterion, NAG model. Residual strength, design approaches will be emphasized. Prep. ME 3433.

ME 3440 Advanced Mechanics of Materials (4QH)
(formerly 02.812) Winter Quarter
Embodies the material in ME 3441 and ME 3442. Prep. Admission to the Graduate School of Engineering.

ME 3441 Advanced Mechanics of Materials I (2QH)
(formerly 02.810) As Announced
Review of fundamental stress and deformation concepts; strain energy density; introduction to energy methods with application to beams, frames and rings; Ritz method. Prep. Admission to the Graduate School of Engineering.

ME 3442 Advanced Mechanics of Materials II (2QH)
(formerly 02.811) As Announced
Beams on elastic foundations. Concept of stability as applied to one and two degree-of-freedom systems. Buckling of bars, frames and rings. Prep. ME 3441.

ME 3443 Advanced Mechanics of Materials III (2QH)
(formerly 02.813) As Announced
Selected topics in advanced mechanics; will vary with current interest. Prep. ME 3442, Advanced Mechanics of Materials II or consent of the instructor.

ME 3446 Theory of Shells (2QH)
(formerly 02.815) Spring Quarter, Odd Years
Membrane theory of shells. Analysis of cylindrical shells. General theory of thin elastic shells. Shells of revolution. Prep. ME 3122.

ME 3455 Mechanics of Composite Materials (2QH)
(formerly 02.816) Winter Quarter, Odd Years
Constitutive equations for anisotropic laminated composite materials, and application to the structural response of beams and plates. Bending and buckling of symmetric and non-symmetric laminates. Prep. ME 3121.

ME 3464 Automatic Control Engineering (4QH)
Fall Quarter, Even Years
Embodies the material in ME 3466 & 3467. Prep. ME 3140.

ME 3466 Automatic Control Engineering I (2QH)
(formerly 02.850) As Announced
Study of control action; analysis and design by use of root-locus and frequency-domain techniques. Prep. ME 3142 or permission of instructor.

ME 3467 Automatic Control Engineering II (2QH)
(formerly 02.851) Winter Quarter, Even Years
Further consideration of linear systems including compensation methods and multiple-input. Techniques for the treatment of non-linear systems. Prep. ME 3466.

ME 3468 Robot Mechanics and Control (4QH)
Fall Quarter, Even Years
Kinematics and dynamics of robot manipulators are the focus of the first part of the course. Kinematics cover the development of kinematic equations of manipulators, the inverse kinematic problems, and motion trajectories. Dynamics of manipulators for the purpose of control are covered employing Lagrangian mechanics. The second part of the course focuses on the control and programming of robot manipulators. Steady state errors and calculations of servo parameters are covered. High level programming languages are discussed. Prep. ME 3142.

ME 3470 Vibration Theory and Applications (4QH)
(formerly 02.844) Spring Quarter
Embodies the material in ME 3472 and ME 3473. Prep. ME 3142 or ME 3471.

ME 3472 Vibration Theory and Applications I (2QH)
(formerly 02.842) As Announced
Laplace transformation techniques; phase-plane diagrams; multiple-degree-of-freedom Systems; free and forced vibrations with and without damping. Prep. ME 3471 or ME 3142 or permission of the instructor.

ME 3473 Vibration Theory and Applications II (2QH)
(formerly 02.843) As Announced
Systems with distributed mass and stiffness. Extensional, torsional and flexural vibrations of bars. Prep. ME 3472.

ME 3474 Vibration Theory and Application III (2QH)
(formerly 02.846) As Announced
Selected topics of current interest in vibrations. Prep. ME 3473.

ME 3475 Random Vibration (2QH)
(formerly 02.845) Fall Quarter, Odd Years
Description of stochastic processes. Impulse response and frequency response of linear time-invariant dynamic systems. Correlations and spectra of stationary response. Crossing rates, peaks and envelopes. Failure under random loading. Poisson pulse processes. Measurement, identification, and response problems. Coherence. Space-time correlations and cross-spectra. Digital data processing. Application to vehicles and structures subjected to wide-band excitation. Prep. ME 3473.

ME 3480 The Finite Element Method (4QH)
(formerly 02.949) Spring Quarter
Embodies the material in ME 3481 and ME 3482. Prep. ME 3101 and ME 3102 or consent of the instructor.

ME 3481 Finite Element Analysis (2QH)
(formerly 02.840) As Announced
Introduction to the finite element method. Variational formulations; simple interpolation functions and element stiffness matrices. Triangular and rectangular elements. Assembly technique and constraining of resulting equations. Elementary applications. Prep. ME 3101 and ME 3102 or consent of the instructor.

ME 3482 Advanced Finite Element Method I (2QH)
(formerly 02.947) As Announced
Isoparametic element formulation of higher order and three dimensional elements. Rayleigh-Ritz and Galerkin formulations. Applications of finite element theory to mechanical engineering problems in the areas of solid mechanics, heat transfer, and fluid mechanics. The use of a finite element general purpose commercial package is included. Prep. ME 3481.

ME 3483 Advanced Finite Element Method II (2QH)
(formerly 02.948) Fall Quarter, Even Years
The dynamic finite element formulation with explicit and implicit time integration schemes for transient analysis. Solution methods for finite element equilibrium equations, including material and geometrical nonlinearities. The general structure of computer procedures and codes. Influence of computer aided design technology. Use of an in-house general purpose commercial code is included. Prep. ME 3482.

ME 3500 Computer Aided Graphics and Design (4QH)
Winter Quarter
Basic aspects of interactive computer graphics are covered. Topics include hardware and software concepts, design principles for the user-computer interface, geometrical transformation, display architecture, and data structures. Algorithms for removing hidden edges and surfaces, shading models, and intensity and colors are also covered. The second part of the course deals with the concepts of computational and numerical geometry and design of curves and surfaces. Solid modeling techniques are presented. Discussions of in-house computer aided graphics and Design packages are included. Prep. Admission to the Graduate School of Engineering and programming experience.

ME 3520 Experimental Techniques in Design (4QH)
Winter Quarter
In mechanical engineering, there is usually a need for verification of material properties, response simulation of the designed element, proof tests, and nondestructive testing of components. Design case histories will be utilized in defining appropriate experimentation needed for verification, simulation, proof tests, and inspection. These experiments may include, though they are limited to, tensile, fatigue, fracture toughness, vibration analysis, thermofluid analysis, and nondestructive testing. In this regard, the course will discuss the techniques associated with these experiments and methods of optimization of data and its acquisition. Prep. Admission to the Graduate School of Engineering.

ME 3525 Manufacturing Methods for Engineers (4QH)

Spring Quarter

This course focuses on manufacturing processes and their effects on the design and performance of engineering products. The first part of the course discusses the current processes and their applications. The second part discusses the design and manufacturing of products made of materials such as polymers and composites. Introduction to design and manufacturing of electronic components is included. Laboratory demonstrations are provided to illustrate various manufacturing processes. Prep. Admission to Graduate School of Engineering.

ME 3540 Heat Conduction and Thermal Radiation (4QH)

(formerly 02.910 and 02.913) Winter Quarter

Formulation of steady and unsteady state one and multi-dimensional heat conduction problems. Solution techniques for linear problems including the method of separation of variables, Laplace transforms and integral transforms. Approximate analytical methods. Phase change problems. Non-linear problems. Nature of thermal radiation. Blackbody and radiation from a blackbody. Radiation from a non-black surface element. Radiative exchange among surfaces separated by a non-participating medium. Interaction of radiation with other modes of heat transfer in non-participating media. Numerical techniques in heat transfer are covered in ME 3410. Engineering. This material is also covered in the two 2QH courses ME 3541 and ME 3542. Prep. ME 3100 and undergraduate course in heat transfer.

ME 3541 Heat Conduction and Thermal Radiation I (2QH)

(formerly 02.910) As Announced

ME 3541 and ME 3542 present the same material with same prerequisites as ME 3540, but in two 2QH courses.

ME 3542 Heat Conduction and Thermal Radiation II (2QH)

(formerly 02.913) As Announced

Continuation of ME 3541. Prep. ME 3541.

ME 3544 Convective Heat Transfer (4QH)

(formerly 02.911) Fall Quarter

Fundamental equations of convective heat transfer. Heat transfer in incompressible external laminar boundary layers. Integral boundary layer equations. Laminar forced convection in internal flows. Turbulent forced convection in internal and external flows. Analogies between heat and momentum transfer; the Reynolds, Taylor and Martinelli analogies. Natural convection. Heat transfer in high-speed flow. Transient forced convection. Convection and radiation in non-participating media. This material is also covered in the two 2QH courses ME 3545 and ME 3546. Prep. ME 3100, ME 3210 and undergraduate course in Heat Transfer.

ME 3545 Convective Heat Transfer I (2QH)

(formerly 02.911) As Announced

ME 3545 and ME 3546 present the same material with the same prerequisites as ME 3544, but in two 2QH courses.

ME 3546 Convective Heat Transfer II (2QH)

(formerly 02.911) As Announced

Continuation of ME 3545. Prep. ME 3545.

ME 3548 Radiative Transfer (4QH)

Spring Quarter, Even Years

Electromagnetic background. Fundamentals of radiation in absorbing, emitting and scattering media. Equation of radiative transfer. Approximate methods in the solution of the equation of radiative transfer. Singular-eigenfunction expansion technique. Pure radiative transfer in participating media. Interaction of radiation with conduction and/or convection. The Monte Carlo technique. This material is also covered in the two 2QH courses ME 3549 and ME 3550. Prep. ME 3540.

ME 3549 Radiative Transfer I (2QH)

As Announced

ME 3549 and ME 3550 present the same material with the same prerequisites as ME 3548, but in two 2QH courses.

ME 3550 Radiative Transfer II (2QH)

As Announced

Continuation of ME 3549. Prep. ME 3549.

ME 3552 Two Phase Flow (4QH)

Winter, Even Years

The basic concepts of heat and mass transfer associated with phase change and multi-phase flows. Some of the specific subjects to be discussed are: boiling heat transfer (nucleate boiling, film boiling and bubble dynamics); evaporation and condensation; liquid-gas two phase flow and gas-solid and liquid-solid two phase flows. This material is also covered in the two 2QH course ME 3553 and ME 3554. Prep. ME 3100 (or equivalent) and undergraduate heat transfer.

ME 3553 Two Phase Flow I (2QH)

As Announced

ME 3553 and ME 3554 present the same material as ME 3552 with the same prerequisites but in two 2QH courses.

ME 3554 Two Phase Flow II (2QH)

As Announced

Continuation of ME 3553. Prep. ME 3553.

ME 3556 Heat Transfer Processes in Microelectronic Devices (4QH)

Spring Quarter

Discussion and development of state-of-the art methods used to predict the heat transfer rates from microelectronic devices and packages and to simulate transport phenomena in manufacturing processes associated with microelectronic devices. Topics will be selected from the current literature and may include use of latent heat reservoirs, boiling jet impingement cooling, control volume approaches to extended surfaces, calculation of thermal contact conductances and natural convection in enclosures. Simulation of laser assisted thermophoretic deposition and laser cladding processes will also be developed. This material is also contained in the two 2QH courses ME 3557 and ME 3558. Prep. ME 3100 (or equivalent) and undergraduate heat transfer or consent of instructor.

ME 3557 Heat Transfer Processes in Microelectronic Devices I (2QH)

As Announced

ME 3557 and ME 3558 provide the same material as ME 3556 with the same prerequisites, but in two 2QH course.

ME 3558 Heat Transfer Processes in Microelectronic Devices II (2QH)

As Announced

Continuation of ME 3557. Prep. ME 3557.

ME 3560 Viscous Flow (4QH)

Winter Quarter, Odd Years

Review of conservation of mass, momentum, and energy for compressible viscous flow. Discussion of the mathematical character of the basic equations and analysis of some exact solutions. Investigation of low Reynolds number flow. Exact and approximate approaches to laminar boundary layers in high reynolds number flows. Stability of laminar flows and the transition to turbulence. Treatment of incompressible turbulent mean flow; internal and external flows. Extensions to compressible boundary layers. This material is also covered in the two 2QH courses ME 3561 and ME 3562. Prep. ME 3100 and ME 3210.

ME 3561 Viscous Flow I (2QH)

As Announced

ME 3561 and ME 3562 present the same material with the same prerequisites as ME 3560, but in two 2QH courses.

ME 3562 Viscous Flow II (2QH)

As Announced

Continuation of ME 3561. Prep. ME 3561.

ME 3564 Gas Dynamics (4QH)
(formerly 02.823 and 02.824) Spring Quarter, Odd Years

The consequences of fluid compressibility are studied. Shock waves and the theory of characteristics are discussed with specific consideration given to two-dimensional steady flows and one-dimensional unsteady flows. Additional topics may include axially symmetric steady flow, small perturbation theory, similarity rules, the hodograph method, or some aspects of physical acoustics. This material is also contained in the two 2QH courses ME 3565 and ME 3566. Prep. ME 3210.

ME 3565 Gas Dynamics I (2QH)
(formerly 02.823) As Announced

ME 3565 and ME 3566 present the same materials with the same prerequisites as ME 3564, but in two 2QH courses. Prep. ME 3210.

ME 3566 Gas Dynamics II (2QH)
(formerly 02.824) As Announced

Continuation of ME 3565. Prep. ME 3565.

ME 3568 Computational Fluid Dynamics With Heat Transfer (4QH)

Spring Quarter

Finite difference methods for solving partial differential equations with particular emphasis on the equations of fluid dynamics and convective heat transfer. Integral methods for boundary layers and their coupling to potential flow solutions. Use of coordinate transformations and body-oriented coordinate systems. Application of superposition techniques in convective heat transfer problems. This material is also covered in the two 2QH courses ME 3569 and ME 3570. Prep. ME 3210 and ME 3410.

ME 3569 Computational Fluid Dynamics With Heat Transfer I (2QH)

As Announced

ME 3569 and ME 3570 present the same material with the same prerequisites as ME 3568, but in two 2QH courses.

ME 3570 Computational Fluid Dynamics With Heat Transfer II (2QH)

As Announced

Continuation of ME 3569. Prep. ME 3569.

ME 3580 Statistical Thermodynamics (4QH)
(formerly 02.904) Spring Quarter, Even Years

An introductory course in statistical thermodynamics for Mechanical Engineers designed to provide insight into the laws of classical thermodynamics and the behavior of substances. Topics to be covered include: Introduction to probability; elementary kinetic theory of an ideal gas including the distribution of molecular velocities and the mean free path treatment of transport properties; classical statistics of independent particles, equipartition of energy, the partition function and laws of thermodynamics; some results from quantum mechanics, quantum statistics of independent particles; applications to gases; introduction to ensembles and systems of interacting particles. This material is also contained in the two 2QH courses ME 3581 and ME 3582. Prep. ME 3100 and ME 3200 or equivalent.

ME 3581 Statistical Thermodynamics I (2QH)
(formerly 02.904) As Announced

ME 3581 and ME 3582 present the same material with the same prerequisites as ME 3580 but in two 2QH courses.

ME 3582 Statistical Thermodynamics II (2QH)
(formerly 02.904) As Announced
Continuation of ME 3581. Prep. ME 3581.

ME 3584 Fundamentals of Combustion (4QH)
(formerly 02.927) Fall Quarter, Even Years
Comprehensive treatment of the problems involved in the combustion of liquid, gaseous, and solid fuels in both laminar and turbulent flow. The fundamentals of chemical kinetics will be discussed. The equations for the transport of mass, momentum, and energy with chemically reacting gases will be examined. Topics will include diffusion and premixed flames, combustion of droplets and sprays, and gasification and combustion of coal. This material is also presented in the two 2QH courses ME 3585 and ME 3586. Prep. ME 3200.

ME 3585 Fundamentals of Combustion I (2QH)
(formerly 02.927) As Announced
ME 3585 and ME 3586 present the same material as ME 3584, with same prerequisites, but in two 2QH courses.

ME 3586 Fundamentals of Combustion II (2QH)
(formerly 02.927) As Announced
Continuation of ME 3585. Prep. ME 3585.

ME 3600 Advanced Physical Metallurgy III (2QH)
(formerly 02.956) Spring Quarter, Odd Years
The kinetics of phase transformations in metals. Topics include kinetic theory, empirical kinetics, diffusion in metals, nucleation, diffusional growth, martensitic transformations. Prep. ME 3620.

ME 3601 Thermodynamics of Materials III (2QH)
(formerly 02.963) Spring Quarter, Odd Years
The application of metallurgical thermodynamics to various process metallurgical problems, i.e., gas-solid systems, etc., plus kinetics of reactions and dynamic systems analysis. Prep. ME 3260.

ME 3602 Materials Science and Engineering III (2QH)
(formerly 02.972) Spring Quarter, Even Years
Continuation of ME 3271 plus a discussion of various special topics that will vary from year to year. Examples are: metastable phases and thin films. Prep. ME 3271.

ME 3603 Corrosion (2QH)
As Announced
The study of the thermodynamics of corrosion and corrosion reactions both in aqueous and non-aqueous environments. Topics will include thermodynamics, kinetics, and the effects of environment and physical metallurgy. Prep. Admission to the Graduate School of Engineering.

ME 3604 Oxidation (2QH)
As Announced
The study of the thermodynamics of oxidation and the effect of environment on rates of oxidation. Topics will include thermodynamics, kinetics, mechanisms, and effect of environment. Ferrous and non-ferrous metals as well as polymers will be assessed. Prep. Admission to the Graduate School of Engineering.

ME 3605 Electronic Materials I (2QH)
Fall Quarter, Odd Years
Generic techniques for fabrication and processing, and the resulting structure-property relationships, are presented for materials utilized in electronics. Typically included are: bulk single crystals, thin films, metals, semi-conductors, and insulators. Prep. ME 3271.

ME 3606 Electronic Materials II (2QH)

Winter, Odd Years

Continuation of ME 3605. Prep. ME 3605.

ME 3610 Introduction to Diffraction Methods in Material Science (2QH)
(formerly 02.975) As Announced
General principles of the diffraction by materials of short wave length radiations; (such as x-ray, electrons, and thermal neutrons) are studied with emphasis on the understanding of the similarities and differences of the different radiations when applied to the study of the structures of crystalline and non-crystalline materials. Prep. A recent introductory material science course.

ME 3611 Diffraction Methods in Material Science (2QH)
(formerly 02.976) As Announced
Continuation of ME 3610 with emphasis on the experimental methods and applications. This includes: choice of radiation, introduction to instrumentation, sample preparation, methods of detection and recording of the diffracted radiation, analysis, interpretation and use of the results. Prep. ME 3610.

ME 3612 Microstructure Analysis I (2QH)

Fall Quarter, Even Years

Discussion of the principles of scanning and transmission electron microscopy. Image interpretation in transmission electron microscopy with emphasis on the study of the relationships between microstructure and properties of materials. Application of kinematical and dynamical theories of electron diffraction to quantitative analysis of point defects, dislocations, precipitates and grain boundaries etc.. Laboratory demonstration of TEM and SEM operation. Prep. Admission to the Graduate School of Engineering.

ME 3613 Microstructure Analysis II (2QH)

Winter, Even Years

Continuation of ME 3612. Prep. ME 3612.

ME 3620 Powder Metallurgy (2QH)
(formerly 02.985) Spring Quarter, Even Years
Powder characteristics and methods of manufacture. Powder pressing: packing, interparticle bonding, effects of pressure. Principles of sintering. Characteristics and properties of products made from powdered materials. Prep. A recent introductory material science course.

ME 3625 Physical Ceramics I (2QH)
(formerly 02.965) Fall Quarter, Even Years
Introduction to ceramic fabrication processes. Characteristics of vitreous and crystalline solids, structural imperfections, and atomic mobility. Phase equilibria, nucleation, crystal growth, solid-state reactions, non-equilibrium phases, and effects on the resulting micro-structure of ceramics. Prep. A recent introductory material science course, physical chemistry or solid state physics.

ME 3626 Physical Ceramics II (2QH)
(formerly 02.966) Winter, Even Years
Discussion of effects of composition and microstructure on the thermal, mechanical, optical, electrical, and magnetic properties of ceramic materials. Prep. ME 3625.

ME 3630 The Structure and Properties of Polymeric Materials I (2QH)
(formerly 02.958) Fall Quarter, Even Years
Introduction to the organic chemistry of polymers, effect of chemical composition on structure, melting point and glass transition temperature, polymer characterization and degradation, thermodynamics of polymers. Prep. Undergraduate material science course.

ME 3631 The Structure and Properties of Polymeric Materials II (2QH)
(formerly 02.959) Winter, Even Years
Rheology and mechanical behavior of polymers, analysis and testing, effects of processing on structure and physical properties, industrial polymers, resin base composites. Prep. ME 3630.

ME 3640 Computer Modeling of Materials Processing (2QH)
As Announced
Focus is on the use of numerical methods for modeling a variety of materials processes, e.g. melting, oxidation, reduction, the blast furnace, the cupola, rolling, extrusion. Prep. Admission to the Graduate School of Engineering.

ME 3641 Computer Modeling of Materials Properties (2QH)
As Announced
Various mathematical techniques and computer methods will be used to develop models that describe the changes in a material's chemical, mechanical, and physical properties as the chemical composition and metallurgical variables are changed. Prep. Admission to the Graduate School of Engineering.

ME 3797 Engineer Degree Continuation (0QH) Any Quarter

ME 3798 Master's Degree Continuation (0QH) Any Quarter
(formerly 02.9X1)

ME 3799 PhD Continuation (0QH) Any Quarter

ME 3850 Special Problems in Mechanical Engineering (2QH)
(formerly 02.992) Any Quarter
Theoretical or experimental work under individual faculty supervision. Prep. Consent of department faculty.

ME 3853 Special Topics in Mechanical Engineering (2QH)
(formerly 02.993) Any Quarter
Topics of interest to the staff member conducting this class are presented for advanced study. Prep. Permission of department faculty.

ME 3854 Special Topics in Mechanical Engineering (4QH)
Any Quarter
Topics of interest to the staff member conducting this class are presented for advanced study. Prep. Permission of department faculty.

ME 3856 Doctoral Reading (2QH)
(formerly 02.994) Any Quarter
Material approved by the candidate's advisor (only S or F grades will be assigned for this course). Prep. Passing of PhD Qualifying Exam.

ME 3860 Thesis (Master of Science Degree) (6QH)
(formerly 02.991) Any Quarter
Analytical and/or experimental work conducted under the direction of the faculty in fulfillment of the requirements for the degree. First-year students must attend a graduate seminar program which will introduce the students to the methods of choosing a research topic, conducting research, and preparing a thesis. Successful completion of the seminar program is required. Prep. Admission to the Graduate School of Engineering.

ME 3861 Thesis (Master of Science Degree) (4QH) Any Quarter
Analytical and/or experimental work conducted under the direction of the faculty in fulfillment of the requirements for the degree. First-year students must attend a graduate seminar program which will introduce the students to the methods of choosing a research topic, conducting research, and preparing a thesis. Successful completion of the seminar program is required. Prep. Admission to the Graduate School of Engineering.

ME 3862 Thesis (Master of Science Degree) (2QH) Any Quarter
Analytical and/or experimental work conducted under the direction of the faculty in fulfillment of the requirements for the degree. First-year students must attend a graduate seminar program which will introduce the students to the methods of choosing a research topic, conducting research, and preparing a thesis. Successful completion of the seminar program is required. Prep. Admission to the Graduate School of Engineering.

ME 3870 Thesis (Mechanical Engineer Degree) (10QH)
(formerly 02.996) Any Quarter
Analytical and/or experimental work conducted under the auspices of the department. Open to day students only. Prep. Admission to the Mechanical Engineer Degree Program.

ME 3871 Thesis (Mechanical Engineer Degree) (4QH)
Any Quarter
Analytical and/or experimental work conducted under the auspices of the department. Open to day students only. Prep. Admission to the Mechanical Engineer Degree Program.

ME 3872 Thesis (Mechanical Engineer Degree) (2QH)
Any Quarter
Analytical and/or experimental work conducted under the auspices of the department. Open to day students only. Prep. Admission to the Mechanical Engineer Degree Program.

ME 3880 Dissertation (PhD Degree) (0QH)
(formerly 02.995) Any Quarter
Theoretical and experimental work conducted under the supervision of the department. Open to day students only. Prep. Admission to the Doctoral Program in Mechanical Engineering.

ACADEMIC POLICIES AND PROCEDURES

A. Course Registration and Withdrawals

1. Program Approvals
2. Course Selections (Minimum Number of Courses; Choosing Courses)
3. Thesis Continuation
4. Registration Procedures
5. Course Withdrawal Procedures
6. Common Registration Problems and Policies
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B. Grading System

C. Academic Standards and Degree Requirements

1. Academic Classifications
2. Academic Requirements
3. Changes in Requirements
4. Class Hours and Credits
5. Code of Student Conduct
6. Continuity of Program
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8. Incomplete Grades
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10. Time Limitations

D. Administrative Procedures

1. Change in Major
2. Change in Status (Classification)
3. Course Substitution
4. Course Waiver
5. Non-Graduate Engineering Courses
6. Thesis
7. Time Limit Extension
8. Transfer Credit

A - Course Registration & Withdrawals

A1 - Program Approvals

The curricula of the degree programs are given under each department heading. Descriptions of courses are given so that students may obtain a general view of the course coverage. Preparatory courses are indicated to students upon their acceptance. Not all courses are offered every year, but the courses are arranged in such a manner that students may make continuous progress toward their degree. The Graduate School of Engineering issues a circular close to July 1st which gives the expected course offerings for the following academic year and the times at which they will meet.

At the time of Fall Orientation, each full-time student must develop, with the assistance of his or her faculty advisor or the Department's assigned Graduate Officer, a complete program of study. Any subsequent changes must be approved by the advisor or the Department's assigned Graduate Officer. The Graduate School of Engineering makes available Advisor Sheets for program planning. These sheets are to be completed and a copy submitted to the Graduate School before a full-time student may proceed with his or her registration.

A2 - Course Selections

Minimum Number of Courses Required

Part-time students may register for a maximum of six (6) quarter hours per quarter.

Full-time students on Parallel Co-op should register for a minimum of eight (8) quarter hours per quarter in order to maintain their full-time status. Continuous Full-time and Alternating Co-op Students must maintain twelve (12) to sixteen (16) quarter hours per quarter for continuous progress toward their degree. Graduate Assistants should maintain at least eight (8) quarter hours per quarter for full-time status and the assistantship appointment. International Students on an F-1 or J-1 student visa must maintain full-time course loads as outlined above. The only exception to the minimum courseload for full-time status is if a student is in his or her last academic quarter or has completed all degree requirements and is registered in thesis continuation.

Choosing Courses

In selecting courses, full-time students should follow their advisor's or the Department's assigned Graduate Officer's approved schedule. Part-time students should follow the outlines presented in the department program section and confer with their advisor or the Department's assigned Graduate Officer for additional assistance as needed.

Courses, other than core courses, are offered according to the demand and the availability of faculty for specific areas. The student should preselect courses whenever possible and plan to take them when offered, maintaining flexibility with alternate courses in mind. There is no guarantee that any particular course will be offered, but the Graduate School of Engineering will do everything possible to assure continuity of programs.

To register for a course offered by a Graduate School at Northeastern other than Engineering, approval from the Graduate School of Engineering must be obtained before a student can petition the other graduate program. Refer to Administrative Procedures under the "Non-Graduate Engineering Courses" section.

Those students who need assistance in course selection, course sequencing, waivers and transfer credits should contact their advisor or the Department's assigned Graduate Officer or the Graduate School of Engineering. Additional information is provided under Administrative Procedures.

A3 - Thesis Continuation

Students who have not completed their thesis after having registered for the specified number of thesis credits must register for Thesis Continuation each subsequent quarter during the academic year until the thesis is completed. Thesis continuation carries no credit, but will appear on the student's transcript along with the appropriate grade for each quarter of registration. The continuation fee is one-half the tuition cost of one quarter hour for Master of Science and the cost of one quarter hour for Doctoral Degrees and Doctor of Engineering. Students who fail to register for Thesis Continuation will be charged retroactively at the time of degree conferral for any quarters in which they did not register and pay for their continuation fee.

A4 - Registration Procedures

Registration is mandatory. Any student who has failed to register properly before the end of the fifth week of classes will not receive a grade at the end of the quarter, even if the coursework was completed.

Engineer Degree, PhD and DEng students must register for course work or dissertation as approved by their advisors or the departmental registration officer. After the first registration for this work, registration must be continuous unless withdrawal is allowed by the committee in charge of the degree program. Doctoral students must be registered for dissertation during the quarter in which they take the final oral examination.

Mail registration is available for all regularly scheduled courses in all academic quarters. Materials are mailed at least four weeks prior to the quarter to all currently active students with the exception of Special Students. The forms should be completed and returned as soon as possible to the Registrar's Office. Course entrance is granted on a first-come, first-serve basis, and past experience indicates that many courses close-out early in the registration process.

For adding or dropping courses following the mail registration period, students must go to the physical registration site to complete add/drop forms. In addition there is a late registration period during the first week of classes at which further changes may be made.

Students planning to graduate within the calendar year are required to complete the pink Commencement Card available in the Registrar's Office and at all registration sites, and file no later than the beginning of the quarter prior to graduation.

A5 - Course Withdrawal Procedures

In order to withdraw from a course, a student must fill out an official withdrawal form obtained at the Registrar's Office or at the Suburban Campus Office. In unusual circumstances, the Registrar's Office may be informed by letter. Withdrawals may be made through the ninth week of the quarter. However, withdrawals which are made after the fifth week of the quarter will be recorded with a "W" on the student's transcript.

Ceasing to attend a class, or simply notifying the instructor of intention to withdraw, does not constitute an official withdrawal. Students will be charged for the course tuition and will be subject to grades of "I" or "W" should they fail to officially withdraw.

Tuition refunds are granted only on the basis of the date on which the form is filed with the Registrar's Office. Students should keep their copy of the course withdrawal form to avoid any possibility of error. The Bursar's Office will credit a student's account or refund tuition in accordance with the following schedule:

Official Withdrawal Filed Within	%Tuition Refunded
First week of quarter	100%
Second week of quarter	75%
Third week of quarter	50%
Fourth week of quarter	25%

Requests for withdrawal from a course after the ninth week of the quarter may be submitted in writing to the Director of the Graduate School, and may be approved to avert unusual hardships on a student.

A6 - Common Registration Problems and Policies

Students who have pre-registered by mail will receive notification from the Registrar's Office in the event any selected course has been filled. The student must attend physical registration to register for an alternative course. However, if the closed course notification is received before physical registration, the student may call the Registrar's Office and verbally request that the course be replaced with the alternative course.

Class sizes are controlled by the Registrar and set by the Director of The Graduate School of Engineering in conjunction with the departments. The number of students enrolled in each class is limited to permit effective teaching at the graduate level. The University reserves the right to cancel, postpone, combine, or modify any course.

To register properly for any closed course, a student must obtain a "Permit to Register" card from the Graduate School of Engineering and submit the card at a scheduled registration. All appeals to enter a closed course must be submitted to the Director of the Graduate School for approval. Such permission is granted in cases where 1) the student has a prospective date of graduation the following June, the course is essential to his or her program, and the course cannot be taken in any of the following quarters, or 2) the student has successfully completed the first part of a sequential course. The addition of the student's name to the class list by the instructor does not constitute registration and will not entitle the student to a grade even if all the coursework is completed.

Due to last minute scheduling changes occasionally the Graduate School will substitute faculty or change times for the class meetings after registration has begun. Any student who initially registered for the original course will automatically be registered for the new version should no major schedule conflicts be apparent. Otherwise, all registered students will be contacted for alternatives. Wherever possible, the Graduate School will attempt to satisfy these students' first options. Once the student has received notification of a time change and when the alternative results in a schedule conflict the student is responsible for making any registration changes.

Graduate Assistants must follow standard procedures for registering, dropping and adding courses. Registration conflicts with regard to work or teaching schedules must be resolved by the Graduate School and not the Registrar's Office.

Students are asked not to register for an excessive number of courses or double sections with the intention of dropping half or more of the courses during the first week of classes. "Double Section" requests will not be processed by the Registrar's Office. Over-registering complicates course and room scheduling, closes courses prematurely to genuinely interested students, and increases the number of changes and thus the chance of error. Students who abuse the registration process will jeopardize their program status.

Course credits earned in the Graduate School of Engineering are valid for a maximum of seven years in the Master of Science degree program, and up to five years in the Engineer Degree and PhD programs (once PhD degree candidacy has been established). (Refer to the Administrative Procedures section).

All students who change their address, name or phone number during their enrollment in the Graduate School of Engineering should inform the Registrar and Graduate Engineering Office separately and in writing.

Any student who is financially withdrawn prior to the start of any given quarter must clear his or her financial obligation by the end of the fifth week of the quarter in order to receive academic credit. No grades will be processed for any student who remains financially withdrawn after the fifth week of any given quarter.

A7 - Student I.D. Cards and Parking Stickers

Part-time students will receive ID's in the mail approximately the second week of classes. If the ID card is lost, a replacement may be obtained through the Registrar's Office.

Full-time students receive photo ID cards during the Fall Orientation week; these are validated with the sticker the student may obtain from the Registrar's Office during the second week of each quarter that he or she is registered.

Parking stickers are obtained from the Traffic Office or the Suburban Campus Office by submitting a Cashier's payment card, car registration, driver's license and proof of registration (ID card or facsimile). Parking space is available on a first-come, first-served basis.

B - Grading System

The student's performance in graduate courses will be graded according to the following numerical equivalents.

A	(4.000)	This grade is given to those students whose performance in the course has been of very high graduate caliber.
A-	(3.667)	
B+	(3.333)	
B	(3.000)	This grade is given to those students whose performance has been at a satisfactory level.
B-	(2.667)	
C+	(2.333)	
C	(2.0)	This grade is given to those students whose performance in the course is not at the level expected in graduate work.
C-	(1.667)	
F	(0)	This grade is given to those students whose performance in the course is unsatisfactory.

In addition, the following letter designations are used:

I	Incomplete	This grade is given to those students who fail to complete the work of the course; this work must be completed within one calendar year.
W	Withdrawal	This grade is given to those students who were officially registered at the end of the fifth calendar week of a quarter and then officially withdrew from the class.
L	Audit	This grade is given to those students who were officially registered to audit the class.
S	Satisfactory	These grades are given to those students officially registered in Thesis courses or Thesis Continuation. A grade is submitted when the Thesis is successfully completed.
U	Unsatisfactory	

Individual faculty members may choose not to use the plus and minus designations. If they elect to use the whole letters only, they must announce this to the class at the beginning of the quarter.

C - Academic Standards and Degree Requirements

C1 - Academic Classifications

Students initially entering the Graduate School are classified into one of three groups according to their admission qualifications:

1. Regular students are those who meet in full all admittance criteria based on the standards established by the Committee on Graduate Study in Engineering.
2. Provisional students are those who do not qualify for regular admission based on the standards established. In order to continue in the Graduate School of Engineering and be reclassified as a regular student, a provisional student must obtain a 3.00 grade point average in their first twelve quarter hours of course work.
3. Special students are placed in a non-degree status and are limited to a maximum of twelve quarter hours of graduate credits.

C2 - Academic Requirements

All students must satisfactorily complete an approved program of correlated work of graduate caliber and such other study as may be required by the department in which he or she is registered. Regardless of classification, any student whose record is not satisfactory may be withdrawn from the Graduate School of Engineering.

To qualify for any degree from the Graduate School of Engineering a student must have a grade point average of not less than 3.00 with no more than 12 credits below a B- in all courses applied towards the degree, exclusive of pre-requisite courses. The Committee on Graduate Study in Engineering allows eight quarter hours of credit to be taken beyond the stated degree requirements, to repeat failed required courses or substitute for elective courses to obtain the required 3.00 average for completion of degree requirements.

Within the above limitations for extra or repeated courses, a required course for which a grade of F is received must be repeated with a grade of C- or better.

Students who wish to audit a course must indicate this preference at registration. While no credit will be given for an audit, audits do appear on the student's transcript. Registration changes from an audit to a graded status in a course may not be made after the first day of classes.

C3 - Changes in Requirements

The continuing development of the Graduate School forces frequent revision of curricula and in every new bulletin some improvements are indicated. Students are held to the requirements in the bulletin of the year in which the student matriculated. However, they may elect to pursue the revised program requirements upon departmental approval.

C4 - Class Hours and Credits

All credits are entered as quarter hours. A quarter hour of credit is roughly equivalent to three fourths of a semester hour credit. All classes meet on a quarter basis. In the summer session, classes meet for two, six-week periods. The academic calendar in the Graduate Student Handbook should be consulted for the opening and closing dates of each academic quarter.

C5 - Code of Student Conduct

The Graduate School of Engineering will take immediate disciplinary action in all cases where a student has failed to adhere to the University rules and regulations for proper student conduct. Cheating, fabrication, facilitating academic dishonesty, and plagiarism are considered violations which may result in immediate dismissal from the Graduate Engineering program. Students should refer to the University Graduate Student Handbook for additional information.

C6 - Continuity of Program

Students are expected to maintain continuous progress toward their intended degree. A student who has attained 8 quarter hours of incomplete (I) grades and/or withdrawals may, at the discretion of the Committee on Graduate Study in Engineering, be withdrawn for failure to show continuous progress toward the degree.

C7 - Filing for the Degree

Each student who plans to graduate either in June or September must submit to the Graduate Registrar's Office a completed commencement data card prior to the deadline listed in the academic calendar for that commencement at which he or she expects to receive the degree. If the deadline for filing is not met, there is no assurance that the degree will be awarded that year. The commencement data card is supplied with the registration materials or is available in the Graduate Registrar's Office. It is, of course, the student's responsibility to make sure that degree requirements have been met, subject to confirmation by the Graduate School of Engineering.

C8 - Incomplete Grades

The I grade will be changed to a letter grade when the deficiency which led to the I is corrected to the satisfaction of and in the manner prescribed by the instructor in the course. The period for clearing such a grade will be restricted to one calendar year from the date of its first being recorded on the student's permanent record.

C9 - Prerequisite/Advanced Undergraduate Courses

Prerequisite courses will not be given credit towards degree requirements unless expressly clarified by the individual departments. Advanced undergraduate courses are sometimes approved for degree credit. A request must be made on a graduate engineering petition form and submitted to the Graduate Engineering office for approval. (See the Administrative Procedures section). The maximum number of credits allowed is determined by each academic department and are specified under the course descriptions for each department.

C10 - Time Limitations

Course credits earned in the program of graduate study, or accepted by transfer, are valid for a maximum of seven academic years in the Master of Science degree programs, up to five years in the Engineer Degree programs, and up to five years in the PhD and DEng programs once degree candidacy has been established. (Refer to Administrative Procedures section under "Time Limit Extension" petitions).

D - Administrative Procedures

D1 - Change in Major*

A change of major area of concentration within the same department may be done on a petition form obtained from the Graduate Engineering office. The completed petition, along with an unofficial transcript of your graduate work, should be presented to your advisor or the Department's assigned Graduate Officer for his or her approval. All of these materials are then filed with the Graduate Engineering office for final approval and changing of your major code with the Registrar's Office.

D2 - Change in Status*

A change of status from full-time to part-time in the same program may be done by filing a completed petition with the Graduate Engineering office. No advisor's signature is needed. Due to immigration regulations students on an F-1 or J-1 visa cannot request part-time status. If you are having academic difficulties, the Graduate Engineering School will recommend a remedial course of action for you.

To change status from part-time to full-time in the same program, you will need to have completed a minimum of 12 QH with at least a 3.0 grade point average. Present a completed petition and unofficial graduate engineering transcript to your advisor or the Department's assigned Graduate Officer for approval. All of these materials are then filed with the Graduate Engineering office for final approval and changing of your status code with the Registrar's Office.

*Please Note: a change of major or status into a different department requires a re-application process. This can be done by requesting, preferably in writing, the Graduate Engineering office to bring your file before the new department's Admission Committee for review. An unofficial graduate engineering transcript, and any other materials needed, should be provided by you to the Graduate Engineering office.

D3 - Course Substitution

A course substitution is the replacement of a graduate level course already taken with an equivalent graduate level course. The Registrar's Office will automatically designate "Repeat" by a course when you retake the same course. However, when a two-part sequence (as offered in the evenings) is taken to replace the four quarter hour day course equivalent, a special request from the Graduate Engineering office has to be made to the Registrar's Office. In order to have "Substitution" noted by the course on your transcript, you need to file a completed petition with an unofficial transcript and your advisor's or the Department's assigned Graduate Officer's approval with the Graduate Engineering office who will then notify the Registrar.

Please Note: There is an eight-quarter-hour limitation on the number of courses you may repeat or substitute. Also, when the notation of "Repeat" or "Substitute" is beside a course on your transcript, the course's quarter hours and grade are no longer calculated into our overall grade point average.

D4- Course Waiver

A course waiver is the replacement of a required course not yet taken in your degree program with an alternative course. To do this, submit a completed petition and unofficial transcript, with the reason for your request, to your advisor or the Department's assigned Graduate Officer for approval. Then, file all materials with the Graduate Engineering office for final approval. The petition is retained in your file for graduation review purposes.

D5 - Non-Graduate Engineering Courses

To request that an advanced undergraduate engineering course be applied to your graduate degree program, you will need to submit a completed petition with your advisor or the Department's assigned Graduate Officer's approval, and an unofficial transcript of both the undergraduate course (if already taken) and your graduate courses to the Graduate Engineering office. If approved, the course and its grade will be used toward your graduate degree requirements. There is a 4 qh limit on the number of undergraduate credit hours which may be used for the graduate degree.

In order to receive credit for graduate courses at Northeastern outside of the School of Engineering, you will need to obtain approval from the Graduate Engineering office. Submit a completed petition with your advisor's or the Department's assigned Graduate Officer's approval and an unofficial transcript to the Graduate office. Then, if approved, bring your copy of the petition to the graduate school in which the desired course is offered. Usually, you will need to complete a different type of petition for that graduate school at least four weeks prior to the quarter in which the course is being offered. Your copy of the Graduate Engineering petition is verification of approval, and will designate if the non-engineering graduate course is to be applied toward your degree.

Interdisciplinary degree students are not required to follow this procedure when the courses are considered part of the degree program.

Please Note: graduate courses taken in another college at Northeastern, if approved for degree credit, are granted on a course-for-course equivalency and the grade is calculated into your overall grade point average.

D6 - Thesis

Instructions for the preparation of a thesis are available from the Graduate School office, and include proper formatting and procedures for depositing the thesis in Dodge Library. The thesis topic is developed with your advisor and the final thesis is approved in accordance with the regulations of the Graduate School of Engineering outlined in the instructions.

D7 - Time Limit Extension

If you come to a point in your graduate work where it becomes evident that you cannot complete your program within the time limit (seven years for Master of Science degree, five years for Engineer degree and PhD candidates), you will need to request approval for a time extension from the Department Graduate Committee. This requires that 1) a completed petition, with your advisor's or the Department's assigned Graduate Officer's approval, 2) an unofficial graduate engineering transcript, and 3) a letter from you stating the reasons for the request, are on file. Your letter, addressed to the Department Graduate Committee, should also state the specific course of action you plan to take in order to complete your degree requirements, and the length of time needed for the extension. If the extension is approved, all materials are placed in your file for graduation clearance purposes.

D8 - Transfer Credit

The Graduate School of Engineering allows up to twelve (12) quarter hours of credit obtained from another institution to be used toward the Master of Science degree. To be eligible for transfer credits, the course(s) must be 1) in the student's field of study, 2) at the graduate level, 3) in a recognized college or university, and 4) carry grades of B or better. The credits cannot have been used toward any other degree and must have been taken within the time limit for your degree completion. Once entered in the program, a student wishing to take a course for transfer credit should petition for approval prior to pursuing the course.

If you are seeking transfer credit approval, you will need to complete a petition, and provide an unofficial transcript of your graduate work at Northeastern, a course catalog description and official transcript of the course you wish to transfer. Submit all of these materials to the Department Graduate Committee. If approved, the material is sent to the Graduate School Office. The credits will be applied toward your degree requirements if all transfer credit criteria have been met. However, the grades do not carry over and are not included in the computation of your grade point average required for degree completion. Credits are granted as equivalent to required or elective courses in the Graduate School of Engineering.

UNIVERSITY FACILITIES AND RESOURCES

In 1910, Northeastern University began new construction on the first piece of land acquired at its present Huntington Avenue site. Since those early days, the central Boston campus has grown to occupy over 50 acres of land located in close proximity to such cultural landmarks as Symphony Hall, the Museum of Fine Arts, the Isabella Stewart Gardner Museum, Horticultural Hall, and the Boston Public Library, among others. The University is within walking distance of Fenway Park, Copley Place, the Back Bay shopping district, and a number of renowned hospitals, including Brigham and Women's and other Harvard teaching hospitals.

In addition to sixteen suburban campus and branch locations, and several off-campus athletic facilities, Northeastern University maintains a variety of affiliations that provide its students access to facilities and specialized equipment at other institutions or organizations.

The Boston Campus

The central Boston campus is built around a quadrangle, one side of which faces Huntington Avenue, a major artery dividing the campus. The buildings surrounding the quadrangle characterize the urban design of the campus, and the innovative design of new buildings that have been added in recent years has maintained an architectural theme that is both attractive and functional.

The campus itself has been planned to provide easy access to classrooms, laboratories, and administrative offices through a series of connected walkways and a network of underground corridors providing routes that are especially convenient during periods of inclement weather. As the University continues to expand, parking and recreational areas are integrated into the campus along with new academic facilities.

Suburban Facilities

Northeastern University's five suburban campuses provide administrative and classroom facilities for the University's graduate, adult and continuing education programs as well as the environment necessary for specific programs of study that could not be accommodated in an urban area.

The Warren Center provides a practical laboratory in outdoor education and conservation, and in camping administration, programming, and counseling. It also offers a summer campsite for various community and University groups and activities and is available as a conference and workshop site.

The Marine Science and Maritime Studies Center is located in the Nahant, on Massachusetts Bay 20 miles northeast of Boston and serves as a site for national and international as well as University research.

Henderson House is Northeastern University's conference center. Located 12 miles from Boston in suburban Weston, Henderson House hosts a variety of round-the-clock activities including residential seminars, workshops, short courses, and weekend meetings.

The Suburban Campus of Northeastern University is located in Burlington near the junction of Routes 128 and 3. Graduate courses in engineering, business administration, and education as well as undergraduate courses for part-time students are offered here. The Burlington Campus also offers special programs for adults and noncredit continuing education courses.

Another Northeastern University facility is the Botanical Research Station in Woburn, which contains a small arboretum and a spacious greenhouse used for propagation and research.

One of the most recent campus acquisitions is the 20-acre Dedham Campus. This recently renovated facility provides space for the College of Business Administration's new High Technology MBA program, and offices for the Center for Continuing Education.

University Libraries

The University Libraries include seven units. On the Boston campus, there is the main facility Dodge, and three libraries that house graduate-level collections; Chemical and Biomedical Sciences, Mathematics/Psychology, and Physics/Electrical Engineering. There are also three libraries located on the Burlington and Dedham campuses and at the Marine Science and Maritime Studies Center in Nahant.

The total holdings of the University Libraries include the equivalent of more than one million volumes in print and in microform, 5,000 periodical titles, 300,000 government documents and 24,000 items in audiovisual and computer software formats.

In the main library, the Learning Resources Center provides computer-assisted-instruction, microcomputer facilities, and language and music listening laboratories. Also housed in the Center is an extensive set of self-paced media materials, in varied interactive formats, including audiotapes, videotapes, and computer-assisted lessons and exercises.

Libraries provide reference assistance and instruction on strategies for bibliographic research. On-line literature searches are conducted, for a fee, by librarians in Computer Search Services. Individual conferences may also be arranged with a librarian to discuss particular or specialized research needs. A series of publications, prepared by the library staff, are available to acquaint students with library collections and services.

Should needed materials not be in the collections of the University Libraries, staff will assist you in identifying other libraries that own a particular title. Requests to borrow books and other materials or to obtain photocopies of articles from other libraries are handled through Interlibrary Loan.

The University's membership in the Boston Library Consortium generally allows Northeastern University students on-site use of consortium libraries at the following institutions: Boston College, Boston Public Library, Boston University, Brandeis University, MIT, State Library of Massachusetts (Amherst, Boston and Worcester campuses), and Wellesley College. Borrowing privileges may also be granted to graduate students who hold a consortium card.

Academic Computer Services

Academic Computer Services supports research activities of faculty, research personnel, and graduate students, as well as teaching and learning activities at both the graduate and undergraduate levels. The computational capability of this facility includes 270 assorted personal computers linked in local area networks at the Boston, Burlington and Dedham campuses. A wide are network also provides both students and faculty with time-sharing access to five large computers through video and hard-copy terminals arranged in clusters at all three campuses. The wide area network connects three Digital Equipment Corporation VAX-11/780 systems in Richards Hall plus an additional VAX 11/785 and a Data General MV/8000 in the Engineering Computer Center. This network also provides access through a number of dial-in computers. A variety of graphics and output devices are also available. Effective utilization of all facilities is promoted by availability of programming assistance at all three campuses.

Electronic spreadsheet and word processing packages are available, as well as numerous software libraries for numerical, statistical and financial applications. The primary languages supported for those who choose to do their own programming are FORTRAN, COBOL, BASIC, PASCAL, and Assembler.

Graduate Student Housing

Full-time graduate students enrolled in a graduate program may reside in a University apartment facility. Assignments are made on a first-come, first-serve basis after an application and deposit are received. There are no accommodations for married students in university housing. The University also maintains listings of off-campus rooms and apartments.

Department of Career Development and Placement

The Department of Career Development and Placement offers a wide range of counseling and placement assistance to all seniors, graduate students and alumni of Northeastern University seeking employment, to undergraduates seeking admission to graduate or professional school; and to students interested in participating in nonpaid, part-time internships in private or public nonprofit agencies for which they may receive academic credit.

Through this department, representatives of hundreds of employers are scheduled to visit the campus each year to interview seniors and graduate students for full-time employment after graduation. A job bank of currently available positions is maintained for alumni who are seeking new opportunities for which they may be qualified. Credential service is provided for students and alumni seeking positions in the field of education and for applicants to graduate and professional schools. Regularly scheduled seminars are conducted for seniors, graduate students and alumni on career development, job-finding techniques, resume preparation and effective interviewing. Individual career counseling is available for seniors, graduate seniors and alumni of all University programs.

Sport, Dance and Exercise Facilities

Through its Cabot Center for Physical Education, Dockser Hall and Barletta Natatorium, Northeastern University offers a wide variety of specialized facilities, including basketball courts, dance studio, indoor athletic field and running track, gymnastics room, combatives room, weight-training rooms, swimming pool, crew practice tank, handball courts, and motor performance and exercise physiology laboratories. The Matthews Arena, with seating for more than 5,000 fans, provides home ice to the University's varsity and subvarsity hockey teams and, when the portable playing floor is down on the ice, home court to the University's basketball teams.

For organized athletics requiring facilities not available on the main campus, Northeastern maintains several off-campus locations, including the Northeastern Boat House, which is located on Memorial Drive in Cambridge and provides a home for the University's crew teams. The Edward S. Parsons Field, on Kent Street in Brookline, is the playing ground for the football, baseball, women's lacrosse and women's field hockey teams, tennis, and some intramurals.

Dedham Track

The recently completed outdoor track and field facility in Dedham has eight lane, Action Trak 200 running surface, and an expansive area for concurrent jumping and field events. This new facility is ready to host dual and championship meet competition, and is a permanent site for Northeastern University track athletes.

Ell Student Center

The Carl S. Ell Student Center provides facilities for student recreation and extracurricular activities. The Alumni Auditorium, with a seating capacity of 1,300, is part of the Center. Also included are special drama facilities, a ballroom, main lounge, fine arts exhibition area, student offices, conference rooms, cafeteria with seating for more than 1,000 and the bookstore.

Lane Health Center

A comprehensive program of medical care is provided to all full-time graduate and undergraduate students. The University maintains a Health Services Clinic, which is open for emergencies at all times and is equipped to deal promptly with any medical condition that may arise. All entering full-time students must submit a pre-entrance physical examination form provided by the Lane Health Center prior to registration. Failure to fulfill this requirement can delay registration and result in a penalty fee and additional fee for a physical examination.

Counseling and Testing Center

Counseling and testing to aid a student or prospective student with career, educational, or personal concerns are available days and certain weekday evenings until 8:30 PM. Information and appointments may be obtained by calling 617-437-2142 or by visiting the Counseling and Testing Center.

Offices of Services for the Handicapped

Any student who has a disability-related special need, no matter how small or individual, can receive ready support services from the Office of Services for the Handicapped (OSH). Frequently, students are uncertain about how they may be aided by this office, and in these situations a discussion of possible alternatives can be quite helpful. OSH provides a wide range of support services to eliminate the competitive disadvantages that a disability may create. Services are individually tailored to meet the needs of each student.

The types of assistance available from the Office of Services for the Handicapped include orientation, registration and preregistration, information clearinghouse, counseling, housing, services for the visually-impaired, the hearing-impaired, the wheelchair user/mobility-impaired student, and learning disabled student.

The Office of Services for the Handicapped is also the gathering place for the Disabled Student Organization of Northeastern University, which works cooperatively with OSH to plan programs and improve accessibility of services for handicapped persons at Northeastern.

Network Northeastern

Network Northeastern represents the University's entry into the age of education by telecommunications. The Network utilizes the microwave-based Instructional Television Fixed Service (ITFS) system whereby educational services are broadcast directly to company sites and other remote locations within a 40-mile radius of Northeastern's Boston campus. With this service, live classroom instruction is telecast in color to remote sites where it is viewed in reception rooms equipped with TV monitors and a telephone-based talkback system. During presentation, off-campus students are able to participate as fully in the instruction as can students sitting in the originating classroom on campus. A courier service is provided to collect and deliver homework assignments, and to serve as the off-campus student's link to the bookstore, registrar, and other campus services.

Network Northeastern currently offers courses in graduate engineering, graduate computer science, undergraduate engineering technology, state-of-the-art professional development courses, and non-credit nursing courses. This instruction is telecast daily between 8:00 a.m. and 10:00 p.m. on four channels to off-campus students at twenty-two company sites and two suburban campuses.

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Academic Calendar 1988-89

Fall Quarter

Registration period	
Burlington 1-3 pm; 5:30-8:00 pm	Sept. 15-16
Boston 9:30-7:00 pm	Sept. 19-22
Classes begin	Sept. 26
Last day to drop a course	Nov. 25
Examination period	Dec. 12-16

Winter Quarter

Registration period	
Burlington pm; 5:30-8:00 pm	Dec. 1
Boston 9:30-7:00 pm	Dec. 5-8
Classes begin	Jan. 3
Last day to drop a course	Mar. 5
Examination period	March 20-25

Spring Quarter

Registration period	
Burlington 1-3 pm; 5:30-8:00 pm	March 8
Boston 9:30-7:00 pm	March 13-16
Classes begin	April 3
Last day to file card for Spring Commencement	May 13
Last day to drop a course	June 3
Examination period	June 12-17
Spring Commencement	June 19

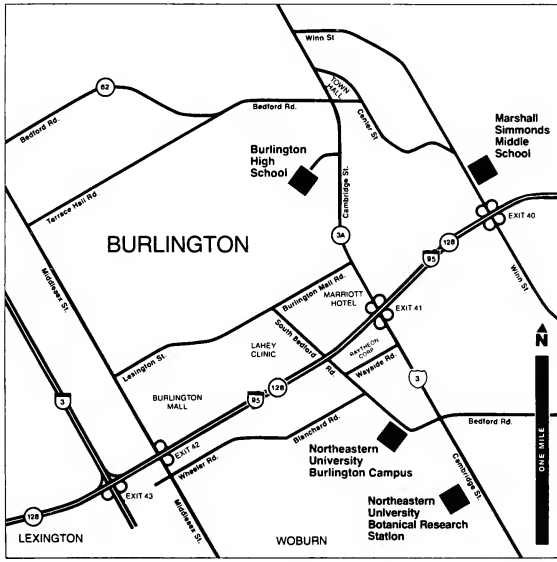
Summer Quarter

Registration period	
Burlington 5:30-8:00 pm	June 13-14
Boston 9:30-7:00 pm	June 14-15
Classes begin	June 26
Last day to file card for Fall Commencement	August 11
Last day to pay fee for Fall Commencement	August 18

Calendar changes may be made. The University Community will be notified if such changes are necessary.

University Holidays

Columbus Day	Monday	October 10
Veterans Day	Friday	November 11
Thanksgiving Recess	Thurs-Sat	November 24-26
Christmas Vacation	Mon-Mon	Dec 19 - Jan 2
Martin Luther King, Jr. Day	Monday	January 16
Washington's Birthday	Monday	February 20
Patriot's Day	Monday	April 17
Memorial Day	Monday	May 29
Independence Day	Tuesday	July 4
Labor Day	Monday	September 4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TOWN HALL
Bedford Rd.
Cedar St.
Marshall Simmonds Middle School
Burlington High School
Cambridge St.
Terrace Hall Rd.
EXIT 40
BURLINGTON
Middlesex St.
Burlington Mall Rd.
MARRIOTT HOTEL
EXIT 41
Winn St.
LAHEY CLINIC
South Bedford St.
RAYTHEON COMPANY
Wayside Rd.
Lexington St.
BURLINGTON MALL
Bedford Rd.
Blanchard Rd.
Northeastern University Burlington Campus
EXIT 42
Wheeler Rd.
EXIT 43
Cambridge St.
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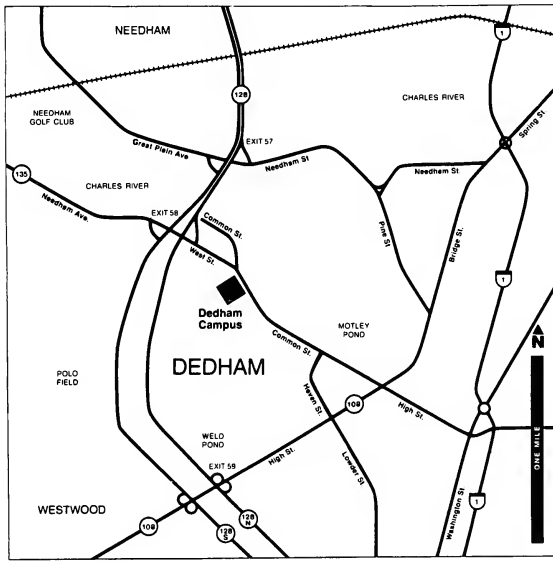
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CHARLES RIVER
Needham Ave.
EXIT 58
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West St.
Pine St.
Bridge St.
Dedham Campus
MOTLEY POND
DEDHAM
POLO FIELD
Haven St.
High St.
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EXIT 59
Lowder St.
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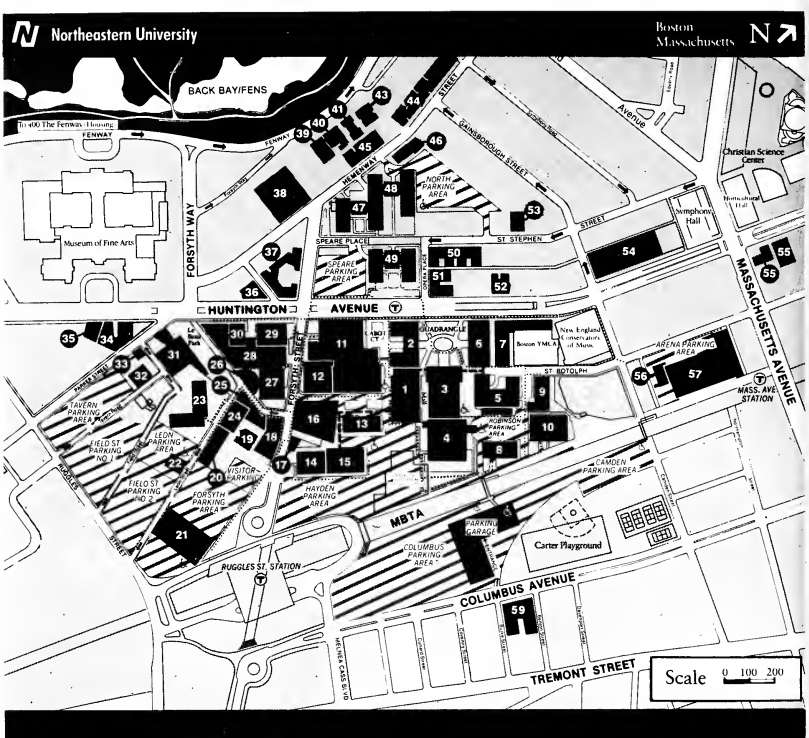
ONE MILE
WESTWOOD



Academic and Service Buildings

- 22 African-American Institute (AF)
- 12 Barletta Natatorium (BN)
- 19 Boiler Plant
- 7 Boston YMCA (BY)
- 11 Cabot Physical Education Building (CB)
- 39 Cahners Hall (CA)
- 28 Cargill Hall (CG)
- 13 Churchill Hall (CH)
- 59 Columbus Place (716 Columbus Avenue) (CP)
- 9 Cullinane Hall (CN)
- 40 Cushing Hall (CU)
- 14 Dana Research Center (DA)
- 27 Dockser Hall (DK)
- 6 Dodge Library (DG)
- 3 Ell Student Building (Auditorium) (EL)
- 4 Ell Student Center (Student Lounge) (EC)
- 16 Forsyth Building (FR)
- 17 Forsyth Building Annex (FA)
- 38 Forsyth Dental Building (FE)
- 1 Hayden Hall (HA)
- 33 Hillel-Frager (HF)
- 24 Holmes Hall (HO)
- 56 236 Huntington Avenue (HU)
- 54 Huntington Plaza (271 Huntington Avenue) (HN)
- 10 Hurtig Hall (HT)
- 26 Kariotis Hall (KA)
- 41 Kerr Hall (Faculty Center) (KH)
- 29 Knowles Center (Gryzmish Hall) (KG)
- 29 Knowles Center (Volpe Hall) (KV)
- 25 Lake Hall (LA)
- 57 Matthews Arena (MA)
- 58 Matthews Arena Annex (MX)
- 20 Meserve Hall (ME)
- 5 Mugar Life Science Building (Peabody Health Professions Center) (MU)
- 18 Nightingale Hall (NI)
- 31 Parker Building (PA)
- 5 Peabody Center
- 2 Richards Hall (RI)
- 8 Robinson Hall (RB)
- 21 Ruggles Building (11 Leon Street) (RU)
- 15 Snell Engineering Center (SN)
- 48 122 St. Stephen Street (SS)
- 30 Stearns Center (ST)
- 55 Symphony Place (334 Massachusetts Avenue) (SY)
- 32 26 Tavern Road (TA)

Residence Buildings

- 34 Burstein Hall
- 51 337 Huntington Ave.
- 43 115–119 Hemenway St.
- 46 142–148 Hemenway Street
- 45 153/157–163 Hemenway St.
- 36 407 Huntington Ave.
- 52 319 Huntington Ave.
- 41 Kerr Hall
- 53 Light Hall
- 42 Melvin Hall
- 35 Rubenstein Hall
- 44 Smith Hall
- 49 Speare Hall
- 48 Stetson East
- 47 Stetson West
- 50 106/110/116/122 St. Stephen St.
- 23 West Apartments
- 37 White Hall
- 7 YMCA

Key

- Academic, Residential, and Service Buildings
- Handicapped Parking
- Handicapped Routes
- Parking Areas
- Street Direction
- Underground Tunnel

Maps are provided by the Visitor Information Center 115 Richards Hall, extension 2736. Some buildings on this map are used but not owned by Northeastern University.

Delivery of Services

The University assumes no liability, and hereby expressly negates the same, for failure to provide or delay in providing educational or related services or facilities or for any other failure or delay in performance arising out of or due to causes beyond the reasonable control of the University, which causes include, without limitation, power failure, fire, strikes by University employees or others, damage by the elements and acts of public authorities. The University will, however, exert reasonable efforts, when in its judgment it is appropriate to do so, to provide comparable or substantially equivalent services, facilities or performance, but its inability or failure to do so shall not subject it to liability.

Northeastern University reserves the right in its sole judgment to promulgate and change rules and regulations and to make changes of any nature in its program, calendar, admissions policies, procedures and standards, degree requirements, fees, and academic schedule whenever it is deemed necessary or desirable, including, without limitation, changes in course content, the rescheduling of classes, cancelling of scheduled classes and other academic activities and requiring or affording alternatives for scheduled classes or other academic activities, in any such case giving such notice as is reasonably practicable under the circumstances.

Northeastern will do its best to make available to you the finest education, the most stimulating atmosphere and the most congenial conditions it can provide. But the quality and the rate of progress of your academic career is in large measure dependent upon your own abilities, commitment, and effort. This is equally true with respect to professional advancement upon completion of the degree or program in which you are enrolled. The University cannot guarantee that you will obtain or succeed at any particular job; that will depend upon your own skills, achievement, presentation, and other factors such as market conditions at that time. Similarly, in many professions and occupations there are increasing requirements imposed by federal and state statutes and regulatory agencies for certification or entry into a particular field. These may change during the period of time when you are at Northeastern and they may vary from state to state and from county to county. While the University stands ready to help you find out about these requirements and changes, it is your responsibility to initiate the inquiry because the University has no other way of knowing what your expectations and understandings are.

In brief, the University is there to offer you educational opportunities and choices and to assist you in finding the direction in which you want to steer your educational experience. But you are a partner in this venture with an obligation and responsibility to yourself.

Northeastern University's Antidiscrimination Policy

Northeastern University is committed to a policy of equal opportunity for all students and employees without regard to race, color, religion, sex, sexual preference, national origin, or handicap or veteran status. The University prohibits discrimination in all matters involving admission, registration, and all official relationships with students, including evaluation of academic performance. Northeastern is also an equal opportunity employer.

Equal Opportunity Employment Policy

Northeastern University is an equal opportunity employer. It is institutional policy that there shall be no discrimination against any employee or applicant for employment because of race, color, religion, sex, age, national origin, or handicap or veteran status.

Northeastern University also prohibits discrimination against any employee regarding upgrading, demotion or transfer, layoff or termination, rates of pay or other forms of compensation, and selection for training. In addition, Northeastern adheres to Affirmative Action guidelines in all recruitment endeavors.

Further, Northeastern will not condone any form of sexual harassment which is defined as the use of unwelcome sexual advances, requests for favors, and other verbal or physical conduct of a sexual nature: as an explicit or implicit condition of employment, as the basis for employment decisions or to interfere with an individual's work performance by creating an intimidating, hostile, or offensive work environment.

Inquiries concerning our equal opportunity policies may be referred to the University Title IX Coordinator/Compliance Officer for Section 504 of the Rehabilitation Act of 1973, Affirmative Action Office, Richards Hall, 437-2133.

Family Educational Rights and Privacy Act

In accordance with the Family Educational Rights and Privacy Act of 1974, Northeastern University permits its students to inspect their records wherever appropriate and to challenge specific parts of them when they feel it necessary to do so. Specific details of the law as it applies to Northeastern are printed in the Student Handbook and are distributed annually at registrations of the University College and graduate schools.

Office of Services for the Handicapped

The Office of Services for the Handicapped (OSH) provides a variety of support services and general assistance to all of Northeastern's disabled students and employees. The University's efforts to comply with the Rehabilitation Act of 1973 are coordinated by the OSH director, 5 Ell Center, (617) 437-2675.

Northeastern University International Mission Statement

Northeastern University, a world leader in cooperative education, acknowledges the increasing interdependence among nations, and, therefore, identifies its mission as preparing its graduates to live and work in an interdependent world. To accomplish this goal, Northeastern University actively seeks qualified students from abroad to enroll in its undergraduate and graduate programs in such numbers and with such geographic origins so as to create and foster a truly global exchange of ideas and values among students, faculty and staff. The University also encourages all colleges to continually develop and expand course offerings to include international issues and cross-cultural aspects and supports faculty to teach and conduct research in the interrelationship among nations and peoples. In addition, the University promotes international understanding and the sharing of ideas with institutions throughout the world by virtue of its faculty and staff exchanges and its study and work abroad programs for students.

Accreditation Statement

Northeastern University is accredited by the New England Association of Schools and Colleges, Inc., which accredits schools and colleges in the six New England states. Accreditation by the Association indicates that the institution has been carefully evaluated and found to meet standards agreed upon by qualified educators.

Tuition and Fee Disclaimer

Tuition rates, all fees, rules and regulations, courses and course content are subject to revision by the President and the Board of Trustees at any time.

Emergency Closing of the University

Northeastern University has made arrangements to notify students, faculty, and staff by radio when it becomes necessary to cancel classes because of extremely inclement weather. AM RADIO STATIONS WBZ (1030), WEEI (590), WHDH (850), WRKO (680), and FM stations WBCN (104.1), and WROR (98.5), are the stations authorized to announce the University's decision to close. Since instructional television courses originate from live or broadcast facilities at the University, neither the classes nor the courier service operate when the University is closed.

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